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An Illustrated Weekly Journal

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ENGINEERING

An Illustrated Weekly Journal

Vol. 184 No. 4788 DECEMBER 13, 1957

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THE SORRY STORY OF THE TECHNICAL COLLEGES

ONE of the strange results of the compromise which was reached two years ago on the future of higher technical education is that the body responsible for approving courses in the new Diploma in Technology has no say in the choice of technical colleges for promotion to the new status of College of Advanced Technology. As a result, in some of these colleges, the National Council for Technological Awards has had difficulty in finding courses of sufficiently high standard to approve, and fears have even been expressed that the quality of some of those approved has not been high enough.

The anxieties of the Council can be read between the lines of their first annual report published last week. They deal with the two major defects of our present arrangements: the shortage of qualified teachers and the inadequacy of buildings and equipment. On the first it is not surprising that they should welcome the report of the Willis Jackson Committee in view of the fact that its energetic chairman is a member of the Council. They believe that the adoption of its recommendations is vital. Of particular urgency are those proposals which would raise the status of the teacher from his present all-too-frequent position as overworked crammer for examinations. These include the reduction of the teaching load; clerical, laboratory and technical assistance; facilities for research; proper accommodation; and opportunities for returning to industry from time to time to refresh his professional experience.

Since the institution of the National Certificates after the first World War the municipal technical colleges have made valiant efforts to fill the gap in the education of professional engineers left by the deficiencies in our system of secondary education and the small numbers of those attending the universities. That higher standards of education were not demanded until recently is evidence of a short-sightedness which can afflict corporate bodies and is only partly redeemed by the imagination and drive of a few adventurous spirits. Now that we are faced with the necessity to bring our system of technical education up to date in the shortest possible time and have decided to build on the existing foundation, it is not surprising that the weakness of the present structure should have been exposed.

The Council makes no comment on teaching methods nor, except by implication, on the quality of teachers. But no one who has experience of what goes on in those many dreary buildings, in which the young apprentice struggles to acquire the certificate which will entitle him to leave the ranks of the mechanic for those of the technician or technologist, can doubt that much of the instruction he receives is uninspired. Certainly it is unsuitable for the student whose daily experience will often involve handling the most advanced machines and processes and in whom the capacity for imaginative thinking needs stimulating just as much as he needs to acquire a store of factual information. Old lectures read and re-read from year to year; simple experiments carried out to routine instructions to satisfy examining bodies; exercises learnt by heart so that they may be repeated on the final day are methods no more suitable for teaching the technician than they are for teaching the engineer.

On buildings, the Council reports the depressing fact that no single college fully satisfies their requirements. In this they confirm the impression given by the report of the Select Committee on Estimates of the House of Commons in 1953. The chief deficiencies are the lack of facilities for project work, of rooms for private study, of accommodation for staff and for student activities. They express the hope that in the current building programme these deficiencies will be corrected; but this will certainly not be so unless their detailed criticisms are taken fully into account in the plans of every new college building or expansion. It is too early yet to judge the merits of the Dip. Tech. award; for this can only be done when its first recipients are demonstrating their abilities in industry, but it will be too late then to remedy defects in the system by which they acquired them.

The present plans for four tiers of colleges may be considered a sufficient break with past tradition to deter the authorities responsible from going any further; but the situation is too serious for vested interests, however admirable from some points of view, to be allowed to act as a deterrent to their further consideration. It may well be that the idea of approving separate courses for the new award, instead of restricting it to whole colleges which reach the required standard, is a mistake. There is a danger that we are spreading our teaching resources and our students round the country in penny packets and preventing the development of a few first-class colleges in which the limited talent for advanced work could be concentrated. Any change in plan at this stage would not only call forth much opposition, but also soon find itself in conflict with the Treasury. Neither of these difficulties is a reason for not uncovering and facing the facts.

Cover Picture.—*In recent years spot welding has been used widely in aircraft construction, as the adoption of stricter process control has improved the quality and reliability of the welds. A light-alloy power-plant component is shown in the photograph; as titanium alloys, stainless steel and nickel alloys replace aluminium, resistance welding is likely to be increasingly favoured.*

* * *

Plain Words

Invention is the mother of progress, and a country that wishes to remain abreast of technical development must encourage its inventors. Patents are the instrument by which the inventor secures his due reward and so provide the stimulus—and the means—to further effort. To keep the inventor waiting three or four years before he learns the outcome of his patent application is to dampen even the most ambitious spirit, yet in Britain to-day such delays are a common experience.

The inventor—or his company—is not the only victim of the situation: other parties can suffer, for their own plans may be held up until they know what patents are held by rivals. This is particularly serious nowadays since invention in any field usually proceeds by a series of small steps made by a number of individuals with competing interests. Each step is an improvement on the last and one may overlap another. The appearance of an improvement by one party stimulates a competitor to make a further advance, and the rate of new development leaves the grant of the corresponding patent protection years behind. This in turn aggravates the situation, for when the patents do appear, their scope and validity become more difficult to assess than they would be if the delay did not occur. The reasons for this unhappy state of affairs are discussed in an article in this issue and remedies suggested. The article is one of a group dealing generally with patents and the patent system.

That the situation is recognised is clear from the provisions of the Patents Act, 1957, which became law some months ago. The effect of this Act is merely to legalise the delay; indeed, many believe it will generally extend it. While the earliest patent applications under prosecution (the tail-enders) will no doubt be expedited, the handling of an average application may in fact slow up. The regulations under the new Act set a final date by which an application must be accepted or it becomes void, and under them it may in many instances be 4½ years before the application must be concluded. No doubt the intention is to reduce the prescribed period step by step, but it remains to be seen with what determination the "squeeze" is introduced. The Act has about it an air of resignation. What is required is a positive effort to seek out and remedy the cause, not a reinforcement of the symptoms.

Unless steps are taken to shorten the acceptance period, the whole patent system may fall into disrepute; inventors may become discouraged and firms come to adopt a policy of close secrecy, preferring to conceal their discoveries than to have them freely exploited by rival concerns. They may go further and cut down their research. Four years is a very long time in terms of technical development: an idea that is useful now and capable of yielding an immediate profit may in a few years be valueless. Four years is too long to make other firms wait to know what they may do, or at least, what liabilities they will have to face. Britain is not alone in this predicament, but for Britain its consequences may be serious.

UNDERWATER OIL TANKERS?

A current research investigation sponsored by Mitchell Engineering, Limited, if it proves fruitful, may lead to a revolutionary advance in the design of oil tankers. The possibilities of nuclear propulsion units for underwater craft have revived interest in the potentialities of high-speed submarine oil tanks, and experiments are now being carried out for Mitchell by Saunders-Roe, Limited, in their towing tanks at East Cowes, on underwater hull forms. These experiments are designed to provide a preliminary basis on which to assess whether, in fact, the competitive economies of the submarine tanker would justify a full-scale research project—a major task that would require backing on a national scale and would involve many sides of the engineering industry.

It has, of course, been announced some months ago that the Japanese are well away with the design of a nuclear powered submarine tanker, but this project by Mitsubishi Heavy Industries, with a deadweight of 30,000 tons and a submerged speed of 22 knots, would appear to be quite a conservative venture in comparison with the British project—if, at this rather nebulous stage, the Mitchell/Saunders-Roe speculations can be considered a project. The concept underlying it is that, given a propulsion unit independent of air supplies and capable of developing very high powers, a small fleet of large high-speed underwater tankers, with a high ratio of payload to deadweight, might well be competitive in cost with the slower conventional surface tanker. The magnitudes envisaged are of the order of 100,000 tons total weight, cruising at speeds of 50 to 60 knots. By operating at depths far below the surface, wave-making resistance, which constitutes the larger part of the drag of a surface vessel, can be drastically reduced, and by suitable hydrodynamic design of the body, at high speeds an overall resistance very much lower than that of a conventional vessel can be obtained. Fig. 1 illustrates, tentatively, the relation between the power required and speed for a surface vessel, a vessel submerged at a considerable depth, and a vessel submerged below the surface at only a fraction of its own length. These figures are extrapolated from earlier test results on small models, and the tests now in hand at Cowes at high speeds and considerable depths may possibly modify the picture.

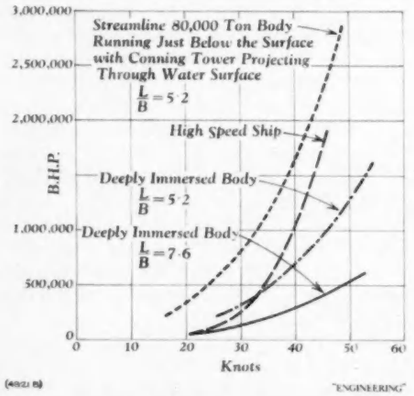


Fig. 1 Approximate power requirements for very high-speed tankers.

MINIMUM DRAG SHAPES

Eight models are to be tested in the Saunders-Roe tank, under the supervision of the tank superintendent, Mr. W. A. Crago. The first six of these have configurations as illustrated in Fig. 2, and the remaining two will be decided on after the optimum characteristics have been approximated from the results on the first six. Each model is 6 ft. long; they vary in length-to-breadth ratio from 7 to 14; five are of circular cross-section, from 0·21 to 0·43 ft.; and one is 0·53 ft. square. The position of the maximum breadth dimension ranges from 40 to 60 per cent. back from the nose. Fig. 4 shows one of the models being towed. Measurements are being taken of the resistance of each model over a range of draughts up to a maximum of 0·3 times the model length and a range of speeds up to 12 ft. per second. The test results corrected for blockage effect and for the resistance of the towing attachment will be plotted to show the effect on resistance of depth and of body shape (length to beam ratio, position of maximum thickness, and change of section shape at constant volume). The model data will be extrapolated to full-scale Reynolds number to provide data for a range of sizes of full-scale bodies so that the effect of size on hydrodynamic efficiency and operating economics can be assessed. The test results will also be correlated with theoretical calculations based on the most authoritative sources available.*

A rough assessment of the effect of body shape on propeller efficiency, and hence the best combination of propeller design and hull form, is also to be made for the full-scale craft. Here, a large element of guesswork is involved, since the propulsion system would itself constitute a major research project. Possible alternatives for the prime mover include steam turbines supplied from a heat exchanger through which the reactor coolant flows; or possibly, the reactor may be gas-cooled and the coolant gas used directly in a closed-circuit gas-turbine; or electrical energy may be derived directly from the nuclear plant.

At the high speeds involved, it seems fairly certain that the propellers will be operating in the fully-cavitating régime and, therefore, they are likely to be of the narrow-blade wedge-section "supercavitating" type, giving much lower friction loss at the operating speed than propellers of conventional design. Their location, too, may be unconventional: although maximum efficiency is likely to be attained with the usual pusher-type propeller, this has the disadvantage of imposing compressive stresses on the shell, and, as will be seen later, one of the virtues put forward for

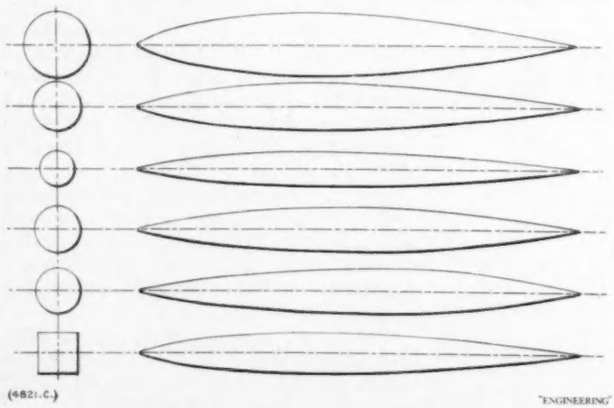


Fig. 2 Shapes of the first six models under test.

* For example, W. C. S. Wigley, "Water Forces on Submerged Bodies in Motion." *Quarterly Trans. Inst. Naval Architects*, July 1957.

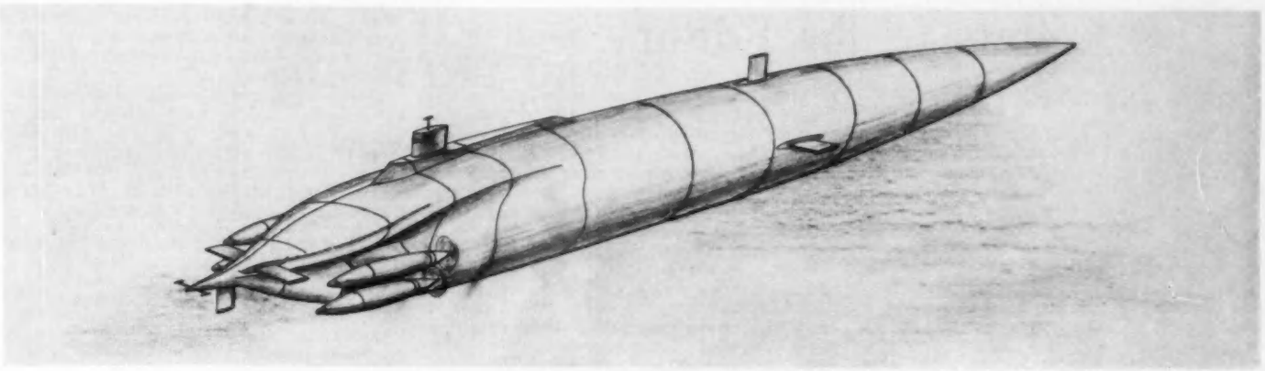


Fig. 3 A possible configuration for a high-speed underwater tanker, of the order of 100,000 tons total weight, cruising at 50-60 knots. From a drawing specially prepared for ENGINEERING.

the underwater tanker is the possibility of using a very light structure. Tractor propellers at the nose or podded pusher propellers amidships are possible alternatives.

A yet more radical solution to the propulsion system might be to use the heat of the nuclear reaction to energise a propulsive water jet—not very efficient, but possibly much simpler to instal than a turbine and shaft drive, and if ample power is available the low efficiency may be a small matter in comparison with mechanical complication.

The structural design of the submarine tanker may well be as unorthodox as its configuration, an artist's impression of which is shown in Fig. 3. Once launched, the tanker will remain submerged continuously. Thus, apart from a very small crew space from which the ship would be remotely controlled by a sophisticated skeleton crew, and apart from the very substantial reactor block amidships, the whole of the vessel would comprise a liquid container. Although hydrostatic pressure at the operating depth may be ten atmospheres or more, the shell structure would serve, in practice, only as a surface of separation of two liquids, and would be very lightly stressed. In the absence of waves, there would be no back-breaking bending moments such as a surface vessel has to cater for, and, as already mentioned, the propeller loads would probably be arranged to act in tension. Unloading of the oil cargo would be carried out underwater, taking in water as the oil was pumped out through flexible pipelines. A retractable conning tower might provide crew exit and entry and a flat walkway above the upper surface could be provided for servicing purposes. For launching, some collapsible reinforcing structure would be required that could be folded up and withdrawn after submersion and changing.

Fig. 4 One of the hull models under test.

Submersion by the control of buoyancy is unlikely to be a feasible proposition, and descent and ascent would most probably be controlled by means of hydrovanes. It seems likely that auto-stabilisation of the vessel both in roll and in pitch would be desirable, and an aircraft type of "joystick" operating control vanes through a servo system might be adopted for controlling the altitude of the craft. Only a very small crew would be required, and, because air-conditioned living space would be severely restricted, both for structural and for air supply reasons, they would require to be specially selected and trained to withstand the psychological strain of confined living.

How would the submarine tanker navigate to its destination, and how could it communicate with the world above? The concept outlined above rules out the possibility of occasional surfacing to check dead-reckoning, and Asdic principles have not yet, so far as we know, been applied to navigational problems. These questions have, as yet, hardly been thought about and, as this brief survey has tried to indicate, many other difficulties—some still unforeseen, no doubt—will have to be tackled before the dream of a fleet of fast underwater tankers becomes a reality.

WATER POLLUTION

By Delwyn G. Davies, B.SC.(ENG.), M.I.C.E., M.I.W.E.*

The doctrine of individual sovereignty over a small stretch of river, its influent and effluent, has produced in the past objection, dispute, injunction and rejection. This ancient river doctrine of *laisser faire* has continued for almost a century and a half, and has inflicted damage to all river users. Gradually a new doctrine is now replacing the old, a doctrine of obligation, a self-imposed agreement by a great majority of firms to accept the rule of water law in the light of common-sense, supported by the slow pressures of statute law. But doctrines do little to ease the serious difficulties which face the iron and steel industry in the control of water pollution, problems which were discussed at a two-day meeting of the Iron and Steel Engineering Group of the Iron and Steel Institute, held in London on December 11 and 12.

The consequences of river pollution are well known, namely, fish poisoning, damage to the water supply, and the potential reduction of the river to a sewer. The daily consumption by Britain's steel industry is greater than that of the combined water demands of the cities of Birmingham, Manchester and Liverpool. Water shortages have enforced on them the careful husbanding of resources until some steelworks have managed to operate on as little as six tons of fresh water per ton of steel produced, by the continuous re-use of the water. Thus, when the quality becomes unsuitable for retention in one circuit, it is bled off to a circuit requiring a lower standard. Through this repetitive re-use, the terminal effluent may be as little as 15 per cent. of the quantity of the intake, some 85 per cent. having disappeared into the air en route.

To the steelworks the effluent problem has no single straightforward solution; the spent liquors contain high toxic concentrations, which require much more complex treatment methods than those common to water-supply or sewage works. The costs, which are not unimportant, may vary between £2 and £7 per thousand gallons. If the modern steelworks can do so much with the almost impossible then the rest of industry surely could do more with the possible. If the whole of industry were as assiduous as the best 10 per cent., then a vast improvement would take place in the cleanliness of the rivers.

Unfortunately the papers hardly mention the influences of extreme dry weather flow on the issue of pollution. It is when the river is decidedly low that the real difficulties arise, for then there is insufficient water for dilution. Industry would do as well to give as much attention to the wider problems of river abstraction as do water engineers to the potential severe droughts on their upland water resources. The effects are identical, a marked absence of water when it is in greatest demand. They must consider how they could carry on if the river flow dropped to 15 per cent. of its normal summer flow.

Difficulties arose during the serious drought of 1921 when the demands on Britain's water resources were about half those of the present day. All those having vital interests in our water resources should peep round the corner of time and ask themselves how the situation can be met in another 30 years when the nation's water demands are double what they are to-day.

* Engineer and Manager, Mid and South-East Cheshire Water Board.

Letters to the Editor

"THE FULL PLASTIC MOMENT"

SIR, I have read the further letters on the plastic theory of bending written to you by Dr. M. R. Horne and Mr. G. W. Deakin, and published on page 615 of your issue of November 15.

Dr. Horne's assertion that the plastic theory of bending gives results sufficiently accurate for engineering purposes is not supported by the quotation of, or references to, any specific conclusive experimental evidence. There has been published from time to time, however, a large amount of authoritative test data on the flexural strength of most structural materials, and little of it could be said to support the plastic theory, except tests on mild steel sections of certain shapes. Bending tests on British Standard rolled T-sections indicate that the proposed theory gives results that are too high (" Results of Experiments on Metallic Beams Bent Beyond the Elastic Limit," by Dr. E. Volterra, *Jnl. I.C.E.*, March, 1945, Fig. 5, page 5) and the results of tests on many materials appear to have no connection with the plastic theory which is merely a crude attempt to explain without finding out " why."

Mr. Deakin's approach to the problem is evidently founded on a lively appreciation of the scientific principles involved. The old elastic theory has served its purpose very well for several generations of engineers, but the time has evidently come when engineers should move into step with advances now taking place in other branches of science. A good line of research has been clearly outlined in Mr. Deakin's letter and it would probably be advisable to move forward in that direction rather than to move backwards towards the old theories which preceded the Coulomb theory of bending and to which the plastic theory appears to be returning.

The further letters of Messrs. J. R. Howgego and D. I. Brindle published on November 22 (page 645) merely serve to confirm Mr. Deakin's fundamental ideas.

Yours faithfully,

TREVOR WELCH.

2 Welbeck-road,
Mansfield Woodhouse,
Mansfield, Notts.
December 3, 1957.

Editor's Note:—This correspondence was commenced by a letter from Mr. A. N. Procter, published in ENGINEERING, October 18, page 487; and a reply by Mr. Procter to the letters referred to above appeared in our issue of November 29, page 677.

TECHNICAL WRITING

SIR, I was interested to read the letter by Mr. A. H. Toms on technical writing in your issue of November 29, page 676, but I would suggest that one of the basic requirements for this occupation has been overlooked.

I agree that " technical writing " requires both a knowledge of the language and an understanding of technical statements, but in my view it is not necessary for a writer to be actively engaged in the research, development, production or use of the article under review.

On this basis the writing seems to fall into two main categories, one where the author is also responsible for the technical work underlying the subject and the other where he is provided with all the technical data on which he constructs his description. In the first case the writer's responsibility covers both technical accuracy and lucid expression, while in the second it concerns mainly language construction, the accuracy of the data being vouched by an authority to whom the manuscript is submitted for technical approval.

It frequently occurs that a person responsible for original technical work is so immersed in that work that his technical writing is undertaken as a sideline and in consequence may be disjointed and not succeed in its instructional purpose. It has been said that a good teacher is one " who can understand somebody not good at explaining and explain it to somebody not good at understanding," and this faculty is required by the writer who derives from others the data required for the preparation of technical instructional publications.

Most technical publications comprise MSS. and illustrations and, to make the combination successful, the technical writer should have a knowledge of the methods of preparation and reproduction of illustrations in a form most suited to the particular subject. Guidance in these matters is given in publications such as that issued by the Institution of Civil Engineers to assist those who aspire to the preparation of learned papers.

While appreciating the points put forward by Mr. Toms, I would with respect suggest that the field of technical writing is more extensive than that suggested in his letter, and in my view it is ambitious to expect " labourers," as quoted in his letter, to be able to undertake successful technical writing, either based on their original work or as technical writers who record the work of others.

Yours faithfully,

P. V. HOARE.

The Knoll,
Morcombelake,
Bridport, Dorset.
December 5, 1957.

LIGHTING AND COLOUR

SIR, Surface mail is slow, and your issue of October 4 containing Mr. K. F. H. Murrell's review of the subject " Lighting and Colour," in his concluding article of the series on " Data on Human Performance for Engineering Designers " (page 438), has only recently reached Melbourne. However, if it is not too late, I should like to make one or two comments in connection with the article.

In the course of his remarks, Mr. Murrell states that " It is important not to confuse reflection factor and brightness." May I respectfully suggest that it is even more important not to be sligntly confused *about* reflection factor and brightness—as he rather appears to be.

The relationship he quotes (namely, that the brightness of a surface is proportional to the product of the incident illumination and the reflection factor) is only strictly true in the case of uniform diffusers, i.e., completely matt surfaces. It is not even approximately true in the case of specular surfaced materials such as the " bright steel " and " bright brass " which he has included in his table of reflection factors for typical materials. The brightness of specular surfaced materials of this kind is hardly affected by the incident illumination, being controlled, instead, by the brightness of whatever surface is seen reflected in them (a fact which anyone can easily check for himself by experimenting with a fragment of mirror, or other highly specular material).

The complete absence of even a passing reference to the essential difference between specular and diffuse reflection factor, therefore, is a pity. A more serious matter, however, is the author's basic confusion over the concept of brightness, betrayed by his reference to the measurement of this quantity in " lumens per square foot." In fairness to Mr. Murrell it should be pointed out that confusion about the nature of brightness is remarkably widespread—mainly because of the all too common practice of mistaking the foot lambert for a fundamental unit. In view of this confusion, it may be worthwhile briefly reviewing the facts of the matter.

Brightness (more correctly termed " luminance "—but let it pass) is defined as the luminous intensity per unit projected area and, in English-speaking countries, the fundamental unit is the candela per sq. in.

Brightness is thus a directional concept (like candlepower) and in only one case can the direction be neglected. This is the case of the uniform diffuser which, by definition, has the same brightness from all angles of view. If a surface of this special kind is emitting or reflecting a total flux of one lumen from each square foot of area, it has a constant brightness of $\frac{1}{144\,\pi}$ cd. per sq. in.

For practical convenience this particular fraction of the candela per sq. in. is given a special name, " foot lambert." This enables the brightness of reasonably non-specular surfaces to be rapidly estimated simply by multiplying the incident illumination by the diffuse reflection factor, as explained by Mr. Murrell; moreover, the answer usually comes out in numbers of convenient size—not in tiny fractions of a unit, as would be the case if the candela per sq. in. was exclusively used.

The foot lambert, therefore, is a very convenient mathematical device, and it may be noted in passing that it is quite legitimate to express the brightness of any surface, specular or non-specular, in whichever of the two units may happen to be the most convenient; converting from one to the other by multiplying or dividing by $144\,\pi$, as required. But it is fundamentally incorrect to express brightness merely in " lumens per sq. ft.," and it is important to realise that, when using the foot lambert, one is not necessarily giving any indication of the total luminous flux emitted. The statement that a surface has a brightness of x foot lamberts in a particular direction actually means: " In the particular direction considered, this surface has exactly the same brightness that a uniform diffusing surface would have if it were emitting x lumens per sq. ft.," quite a big job for just two small words to do.

I feel that the above-mentioned facts about brightness are worth publicising, for lighting is a subject of direct practical importance to most engineers and it seems a pity that such a basically simple matter as the essential nature of brightness should be shrouded in so much fog. My main objective, in fact, is to try to spare others some of the bafflement and confusion that I suffered myself a good many years ago, when trying to visualise brightness in terms of the foot lambert—a hopeless struggle until someone pointed out to me the simple fact that brightness is fundamentally related to luminous intensity per unit projected area, and not to total luminous flux.

Yours faithfully,

J. C. LOWSON.

386 Wattletree-road,
East Malvern,
Melbourne, S.E.5,
Australia.
November 29, 1957.

BICYCLE DESIGN

SIR, I should like to protest at a piece of loose titling in this week's ENGINEERING.

As a cyclist of 40 years' standing (if this is not too contradictory) I read " Stagnation in Bicycle Design?" (page 722) with considerable interest since I always understood that the present design represented almost the ideal one for the job. The content of the article did nothing to disprove this since all the criticism was levelled, not at the design, but at the accessories. Cycle brakes may be affected by wet—in fact they certainly are—but not sufficiently to make the cycle as lethal as a car with faulty brakes which will not work even in dry weather.

Yours faithfully,

F. H. SMITH.

8 Thames-street,
Walton-on-Thames.
December 6, 1957.

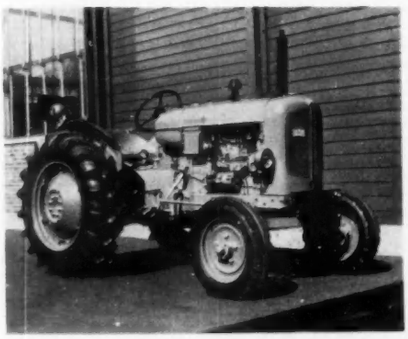
Plant and Equipment

SMITHFIELD HORSES

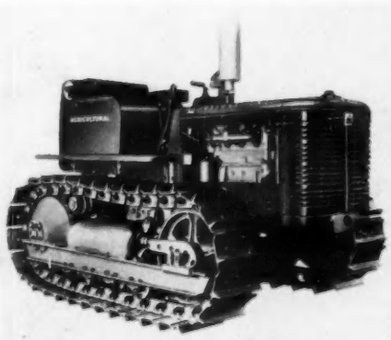
This year's Smithfield Show at Earl's Court, London, was notable for the number of new, or improved, tractors on display. David Brown's "Livedrive" version of their 900 tractor has already been described in these pages (issue of November 22, page 647). Other new models were shown by the Ford Motor Company, the Nuffield Organisation, Massey-Harris-Ferguson and International Harvester.

The Fordson Major tractor has been in service for a number of years, and the Ford Motor Company, Limited, Dagenham, Essex, have now announced the addition of the Fordson Dexta, a three-cylinder tractor for lighter applications than the Major. The Dexta has a 6-speed constant-mesh gearbox and single quadrant control hydraulics. The engine has a bore and stroke of 3·5 in. and 5 in. and develops 32 b.h.p. at 2,000 r.p.m., with a maximum torque of 92 lb.-ft. at 1,200 r.p.m. With a total weight of 2,890 lb., the tractor is light and manoeuvrable, the turning circle being 17 ft. A category 1 linkage is employed which is suitable for most farming equipment. As in the case of the Major, live power-take-off is available with the same double clutch giving also live hydraulics. The standard tyre sizes for the front are 4·00 by 19 and for the rear 10 by 28, with optional variations. The tractor has an adjustment for track width from 48 in. to 76 in. in 4 in. steps to allow it to be used in crop rows of different widths.

Three-cylinder 32 h.p. Fordson Dexta.



The 37 h.p. Nuffield Universal Three.



International Harvester's 42 h.p. crawler tractor.

Another three-cylinder Diesel engined tractor making its first appearance at the show, was the Nuffield Universal Three, produced by Morris Motors Limited (Agricultural Division), Cowley, Oxford. This has an engine capacity of 2·55 litres (155·6 cub. in.—the Dexta has 144 cub. in.) and develops 37·2 b.h.p. at the flywheel at 2,000 r.p.m. The five forward speeds and reverse gearbox gives a range of speeds from ½ to 14 m.p.h. The linkage is suitable for both category 1 and category 2 implements. The power-take-off is extra to the basic model and has an alternative version which can be operated independently of the movements of the tractor itself. The engagement of this latter type is controlled by a separate hand lever. The basic model weighs 3,880 lb. and the addition of belt pulley, hydraulic power unit, drawbar extension, etc., brings this up to 4,330 lb. Without recourse to brakes, the tractor has a turning circle of approximately 11 ft. radius. For row crop work, both front and rear wheels can be adjusted through a wide range.

The new-comer in the Massey-Ferguson group was the "65" which uses a four-cylinder 3·14 litre (192 cub. in.) Perkins engine. This develops 50·5 h.p. at the flywheel at 2,000 r.p.m., so making this tractor the most powerful to embody the Ferguson hydraulic implement-control system. Detachable link ends allow both category 1 and 2 implements to be handled, and there is also provision for fitting a second heavy-duty hydraulic pump for the operation of loaders and other equipment. The gearbox offers six forward and two reverse speeds ranging from 1·32 m.p.h. to 14·4 m.p.h. when the engine is running at 2,000 r.p.m. Power-assisted steering can be fitted and the differential can be locked to give extra traction in difficult conditions. A dual clutch is used to give live power-take-off under all conditions. The total weight of the tractor is 4,010 lb., which is divided so that there is 2,340 lb. on the rear wheels (which have 11 by 32 pneumatic tyres) and 1,670 lb. on the front wheels which have 6 by 16 tyres. Goodyear "Ausco" double disc brakes are fitted, which can be operated either together or independently to assist steering. For row crop work, the front wheels have a track adjustment from 48 in. to 80 in., and the rear from 52 in. to 88 in., both in 4 in. steps.

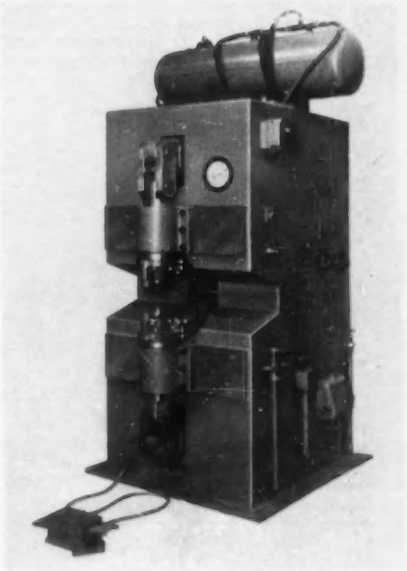
A 42 b.h.p. crawler tractor, built at Doncaster, was the contribution by the International Harvester Company of Great Britain. It is driven by a four-cylinder four-stroke Diesel engine with a displacement of 264 cub. in. The rated power is developed at 1,450 r.p.m. and the maximum torque at 1,000 r.p.m. Bore and stroke are 4 and 5½ in. respectively. The gearbox gives five forward speeds (from 1·5 to 5·4 m.p.h.) and one reverse. In first gear, the drawbar pull (maximum sustained) is 9,600 lb. With a total weight of 8,500 lb., the 12 in. wide shoes give a ground pressure of 6 lb. per sq. in.; wider shoes (14 in. or 16 in.) can be fitted if desired.

Joining the ranks of the agricultural and general purpose Diesel engines made by F. Perkins Limited, Peterborough, was the Four-99, which made its debut at Smithfield. The agricultural version is rated at 35 b.h.p. at 3,000 r.p.m. for a total weight of 456 lb. It is a four cylinder in-line engine with a bore and stroke of 3 in. and 3½ in. respectively, giving a capacity of 1·6 litre (99 cub. in.). C.A.V. distributor-type fuel pumps are used, fitted with either hydraulic or mechanical governors. The compression ratio is 19 to 1. The fuel is injected into a hemispherical combustion chamber machined into the cast iron cylinder head. The lower half of the chamber is formed by an inserted machined plug which contains the throat connecting the chamber to the cylinder. Forced lubrication is employed.

A second new engine by Perkins which appeared at the show was the four cylinder 3·14 litre P4/192 rated at 50·5 h.p. at 2,000 r.p.m. with a maximum torque of 136 lb.-ft. at 1,400 r.p.m. This has a similar combustion system to the Four-99. The bore and stroke are 3·5 in. and 5 in. respectively, and the complete engine weighs 744 lb.

RIVETING MACHINE

A riveting machine designed for heating and upsetting 0·5 per cent. molybdenum-steel rivets into countersunk preparations on turbine discs, has been built by Metropolitan-Vickers Electrical Company Limited, Trafford Park, Manchester, 17. The machine, which is shown in the accompanying illustration, is capable of dealing with rivets up to 3 in. in length and between 0·25 and 0·5 in. in diameter. The purpose of the machine will be made clear when it is explained that each turbine-blade sector is dovetailed into a slot in the outer periphery of the turbine-wheel disc and the rivet is threaded through drilled holes which pass through the disc slot and through the base of the blade sector, thus preventing any movement of the blade in the peripheral slot of the disc.

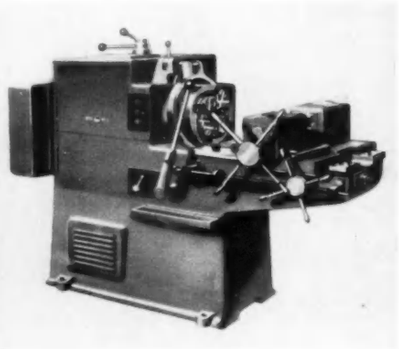


Machine for heating and upsetting rivets into countersunk preparations on turbine discs. Heating currents can be varied between 5,000 and 16,000 amperes and times between 1 and 20 seconds.

A 50 kVA air-cooled single-phase transformer supplies ten values of heating current between 5,000 and 16,000 amperes; the heating time varies between 1 and 20 seconds. A contact force of between 120 and 550 lb. can be applied to the rivets during the heating period and the upset force which follows is adjustable to between 6,000 and 30,000 lb. The pressures required are obtained through a lever and link mechanism from a single air-operated cylinder at the rear of the machine.

Continuing **Plant and Equipment**

BOLT OR PIPE SCREWING

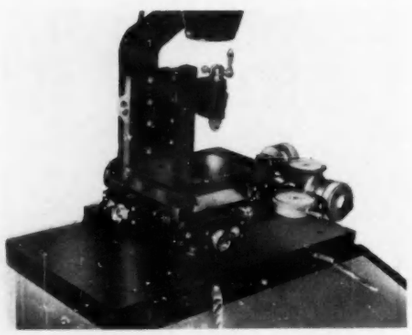


A new screwing machine introduced by Joshua Heap and Company, Limited, Ashton-under-Lyne, completes the re-designing of their single-spindle tangential die head range. The new machine can be fitted with a 3 in. or 4 in. tangential die head, and will thread bolts and pipes from ½ in. to 3 in. or ½ in. to 4 in. diameter accordingly.

An all-geared headstock, with nine speeds, enables the machine to cut all classes of material throughout its range. The main spindle is mounted on phosphor bronze bearings lubricated by a pump in the headstock; all other shafts are ball-bearing mounted. Alternative lengths of bed are available, enabling either 15 in. or 36 in. to be screwed at one setting of the vice. A lead screw is provided for screwing very coarse threads in two passes.

A powerful open-jaw self-centring vice holds the component to be screwed, the vice mechanism being totally enclosed to protect it from swarf. The tangential die head is of the manufacturers' well-known type. It is arranged for automatic opening and closing through the saddle movement, as well as hand operation by a lever on the side of the machine. Threads up to 2 in. Whitworth can usually be cut at one pass, but a double cut device is fitted so that a thread can be cut at two passes without stopping the machine, if necessary.

TOOL-ROOM PROJECTOR

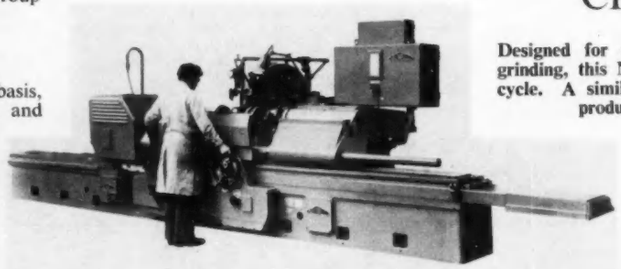


A new measuring projector for use in the tool-room and in production-control inspection, the Shadowmasta VMP, has been introduced by Watson, Manasty and Company, Limited, 139 Richmond-road, Kingston-upon-Thames, Surrey. The instrument has a traverse of 2 in. by 1 in., the accuracy of the squareness of the slides being to within 5 seconds of arc. A drum-type micrometer is fitted, reading in graduations of 0·0001 in. or 0·002 mm., with equivalent dial gauges. Magnifications of 10×, 20×, 25×, 31·25× and 100× are provided; the screen, of satin-etched glass, measures 15 in. by 12 in.

The lamphouse may be raked left or right to accommodate the helix angle of screw threads, a positive location being provided for the vertical position. The precision measuring stage, which is shown in the accompanying illustration, is used in conjunction with one of a range of Shadowmasta charts which provide cross-line grids forming a datum from which readings can be taken. A V-block and centres attachment, with a maximum capacity of 4 in. diameter, is available for use in conjunction with the precision measuring stage.

The new projector, which made its first public appearance recently, at the Engineering Industries Association London Regional Display, was also shown at the Industrial Efficiency and Productivity Exhibition in Manchester from November 15 to 16, by Buck and Hickman Limited, who have been appointed marketing agents for the full Shadowmasta range.

GRINDING CRANKSHAFTS AND CRANKPINS



Designed for crankshaft journal and crankpin grinding, this Newall machine has an automatic cycle. A similar machine is available for high production crankpin grinding.

Two new machines, one for general crankshaft journal and crankpin grinding, and the other for automatic production work on crankpins, are announced by Newall Group Sales Limited, Old Fletton, Peterborough.

CRANKSHAFTS

Designed for grinding on a production basis, or for re-grinding, both main journals and crankpins, the model U/HAC machine has a maximum swing of 28 in., and maximum and minimum distances between the faces of the workhead and tailstock spindles of 84 in. and 36 in. respectively. It incorporates a fully-automatic hydraulic/electric grinding cycle, giving a high rate of output with accurate finishes.

Both workheads are power driven by a common drive shaft from a 5 h.p. motor and a 7-speed gearbox which gives work speeds of 35, 41, 47, 52, 58, 64 and 72 r.p.m. A hand-wheel control provides lateral adjustment of the right-hand workhead centre to facilitate loading during main journal grinding. The heavy-duty wheelhead mounts a 42 in. diameter wheel, and has a 6 in. rapid approach. Four automatic variable rates of infeed are provided, one for face grinding and three for diameter grinding. A micro-adjusted diamond dresser may be clamped in either workhead for dressing the wheel to correct width. In addition, a table-mounted radius dressing attachment is available for journal grinding, and a dresser bar mounted radius attachment is supplied for crankpin work.

Table traverse is hydraulic, with steplessly variable control by joystick. Automatic positioning of bearing or pin and the grinding wheel is effected by a spacer bar and hydraulic plunger on the front of the machine. Separate spacer bars for crankpin and journal grinding are supplied as standard equipment to suit customers' requirements. The throwblocks or clamping heads used for crankpin grinding are easily detachable, and the left-hand member is designed to accommodate a dividing plate suitable for the type of crankshaft concerned. A Newall electro-sizing gauge is fitted, with manual over-riding of wheelhead approach and retraction.

The same simple automatic grinding cycle is used for both crankpins and journals. After location of the table by means of the hydraulic plunger in the spacer bar, the joystick is moved forward, and this starts the workhead and the approach of the wheelhead. Rapid approach takes place to a pre-determined position, then the infeed rate slows down and the crank web faces are ground. Coolant then begins to flow, the infeed rate is again reduced, and grinding of the workpiece diameter commences. This continues with the electro-sizing gauge in position until the workpiece is plus 0·005 to 0·01 in. over the required diameter, when a still slower feed is brought into operation. Finally, just before finished size is reached, the final infeed rate comes into operation, and the electro-sizing gauge takes control, withdrawing the wheelhead immediately the correct diameter is reached.

CRANKPINS

Basically similar to the general purpose crankshaft machine, the A/HAC crankpin grinder is designed for large-scale production grinding under automatic control. It is suitable for four or six-throw crankshafts. Operation of a push-button starts the automatic cycle after the shaft has been loaded and clamped. Wheelhead advance is then automatic, infeed rates being reduced as size is approached. A Sigma air-sizing gauge controls the grinding, and the wheelhead and gauge retract when size is reached. On reaching its rear position the wheelhead operates a control circuit which indexes the table to the next pin in line with the one already ground, and the grinding cycle re-commences. When the second pin has been ground the wheelhead retracts once more, and the table indexes back to the start position, ready for unloading the crankshaft and the loading of a fresh one. Safety interlocks are provided in the automatic cycle circuit, and in addition it can be arrested at any time by push-button. A rotary switch enables the automatic cycle to be cut out and a set of manual push-button controls to be brought in for setting purposes. Suitable equipment is provided for roughing and finish-dressing of the wheel.

Companies in the News

Optimism Well Founded

Demand for electrical machinery and plant continues at a high level and for those few firms in the industry who do not include domestic electrical appliances in their range of products there would seem to be no cause for worry. Mr. Albert Parkinson, chairman of Crompton Parkinson, told his company's shareholders last week that the unexecuted order book was " in a healthy condition." They could " go forward in the belief that, given reasonable business and industrial stability, our optimism in the future is well founded."

Crompton Parkinson's trading profits for the year ended June 30 was up by £164,000 to £2·34 million. It was a year of considerable changes for the company, which included the retirement of their managing director, Mr. J. Harwood Fryer, and a complete re-organisation of the capital structure involving the capitalising of £1·7 million worth of reserves and the raising of the authorised capital by £2½ million. It also saw a widening and growth of the company's interests in nuclear and electronic engineering, accompanied by further expansion and modernisation of manufacturing facilities. The company were a founder member of Atomic Power Constructions, in conjunction with International Combustion and Richardsons Westgarth. With Holland and Hannen & Cubitts Limited, Trollope and Colls, Fairey Aviation and Elliott Brothers, the new nuclear engineering group has, to quote Mr. Parkinson, " all the technical, productive and financial resources necessary to enable it to take a leading part both in the expansion of the country's atomic power programme and in the export of nuclear power equipment."

Tne activities of Crompton Parkinson overseas, with local manufacture in several countries, have continued to increase. They look forward to the formation of free trade areas which " will confront us both with opportunities for the extension of our products and also with more intensive competition." By and large, Mr. Parkinson's story is a hopeful one for British electrical engineering. The recent winning of a very large contract by South Wales Switchgear in Venezuela (placed by Shell Petroleum) against keen Continental and United States competition, is further evidence that the industry is likely to play an increasingly major part in the country's export drive.

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Devolution in Electricity

Wise delegation is the crux of good management. Plans announced last week by the new Central Electricity Generating Board suggest that the Board is fully alive to this dictum. When it takes over the supply and distribution work of the Central Electricity Authority, which comes to the end of its working life on December 31, 1957, more responsibility will be devolved to provincial establishments. Existing generating divisions will be maintained, but will be grouped under five regional directors with a considerable measure of autonomy. These are to be Mr. P. Briggs (North-Eastern and Yorkshire); Mr. R. L. Batley (Midlands and East Midlands); Mr. A. Cooper (Eastern, London and South-Eastern); Mr. A. C. Thirtle (Southern, South-Western and South Wales), and Mr. W. C. Parker (North Western, Merseyside and North Wales). The Board also announced the appointment of Mr. H. J. Bennett as the controller of the London Division and Deputy Director of the Eastern, London and South-Eastern Region.

Devolution is inherent in the terms of the 1957 Electricity Act, under which the monolithic Central Electricity Authority is to be replaced by the Electricity Council, which is to be the controlling body for the industry as a whole, and the Central Electricity Generating Board, which is to be responsible for the " executive " work of the industry. Some further devolution of power was only to be expected sooner or later—for good reasons. The retiring C.E.A. did sterling work under Lord Citrine and in contrast to some other nationalised industries was conspicuous in being able to pay its own way since its inception in 1948. The rapid expansion in demand for electricity in recent years, however, had meant that the C.E.A. was in danger of becoming an overweighted body. During 1956/57 alone, the C.E.A. added about 2 million kW to its generating capacity, and an additional 3 million kW is expected to be added during the two succeeding financial years. Installed generating capacity is now not far short of 26,000 MW, compared to 24,615 MW at the end of 1956, and 17,140 MW at the end of 1952. The greater powers vested in the regional boards should ensure against any spread of Parkinsonism in the electricity industry.

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Trading in Know-How

The case of Moriarty (Inspector of Taxes) versus Evans Medical Supplies Limited was mentioned in ENGINEERING when it came originally before Mr. Justice Upjohn. The facts of the case are briefly that Evans Medical Supplies Limited claim to have parted with " know-how " in building a factory of laboratories for the new pharmaceuticals industry in Burma. In return for this they received £100,000 which they have argued constituted the surrender of a capital asset which should not attract income tax. The issue is obviously important for all concerns who have technical expertise to trade.

The House of Lords dismissed the appeal of the Crown and allowed a cross-appeal by the company from the decision of the Court of Appeal on December 13, 1956. The Court of Appeal had ruled that part of the consideration was of a capital nature and part income, remitting the precise assessment of each to the Special Commissioners.

The House of Lords' decision was by a majority. Viscount Simonds in giving judgment said that the case was a simple one except for one point. It was manifest, in his opinion, that a secret process, whether in composition or methods of storing and packing was something which could be disposed of for value and that by imparting the secret to another its owner did something which could not fairly be described as " rendering a service." The evidence supported the view that in return for £100,000 the company parted with assets which could reasonably be considered as fixed capital. The company had parted with an asset which was the source, or one of the sources, of its profit and had thus parted with its property which in His Lordship's view meant that it had parted with a capital asset.

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Cables in Trouble

Lower profits were a common experience in cable manufacturing during the financial year ended at June or July. Even British Insulated Callender's Cables took a fall. First there was the set back due to heavy falls in the price of copper with consequent stock losses for most companies. Copper fell by £50 a ton during the period and lead by £20. Secondly, cable demand was severely affected by the first round of credit restrictions and was only beginning to recover when the second round took place. Export demand was reasonably good but competition, particularly from countries with low labour costs, was greatly intensified. Two companies whose results were published recently, Scottish Cables (South Africa) and Johnson and Phillips (in their case an interim statement for the first half of 1957) generally confirm the impression given by the reports of other companies. Results are poor and prospects somewhat confused.

The chairman of Scottish Cables (South Africa), Mr. William Frazer, Jnr., takes the view that the industry cannot escape the effects of fluctuations in base metal prices: " . . . despite a continuous effort to avoid losses on a falling market, it must be appreciated that even with most careful purchasing policy certain losses were inevitably bound to arise, particularly in the disposal of stocks of different classes of cable which had to be kept to meet urgent and short deliveries." Johnson and Phillips said that despite a considerable improvement in the trading results for the first half of this year, " the effect of the copper position was still being felt " and the net profit was therefore small.

The chairmen are cautious in respect of the current year's result and generally apprehensive regarding the effect on profits of margins of rising labour costs. The latter are the key to effective competition in overseas markets with Italian, German and other European makers.

The secretary of Johnson and Phillips, Mr. A. B. Adam, said the volume of business up to June 30 was " noticeably greater " due to the impetus given to demand by the " substantial reductions in copper prices." The company's directors felt " reasonably confident that the rate of order input will be maintained and that the trading results will continue to show an improvement." Scottish Cables are more confident and say that they expect a continuous heavy demand for their products " for a very long time."

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Increased Industrial Output in Northern Ireland

The preliminary results of the Northern Ireland census of production for 1956 show an increase in gross industrial output from £413 million in 1955 to £459 million in 1956 and in net output from £120 million to £129 million. The total employed in industry rose from 211,900 to 213,500.

The main industries to show an increase in employment were clothing where the increase amounted to 1,520, food, drink and tobacco (990), and engineering and metals (800). Building and contracting showed a decline of 1,130 and the traditional linen industry a decline of 790. As a result engineering and metals gave employment to 52,700 in 1956 and showed a gross output of £78 million compared with an employment figure of 45,700 and gross output of £67 million for the linen industry.

The past 18 months have been a difficult period for the Northern Ireland Development Council on account of the credit squeeze and of the slowing down of business activity in America. Capital expenditure on plant and machinery at £13,500,000 in 1956 and on new buildings at £4,500,000 were still running at a high level. A further expansion in industrial output may therefore be expected during the current year. Unemployment in June, 1957, was still relatively high at 6·8 per cent. of the insured population and as shown in the study of the Northern Irish economy by Professor K. S. Isles and Mr. Norman Cuthbert considerable additional capital investment is required if this figure is to be reduced. Their report shows that one of the main requirements is to find some means to encourage the investment of Northern Irish capital in Irish enterprises since at present there is a substantial capital export mainly to Great Britain. Lord Chandos, chairman of the Northern Ireland Development Council, recently stressed that under present economic conditions the most satisfactory method of solving Northern Ireland's economic problems would be for local industries to expand their own activities based on an appraisal of the market.

Metals and Materials

ALUMINIUM BUSBARS

Mechanical and Electrical Difficulties Overcome

By H. B. Grainger, B.SC., A.I.M., *and R. J. Watkins*, B.SC.*

Economic conditions have led electrical engineers to restrict their use of copper as far as possible. For busbars, aluminium has the double attraction of cheapness and lightness. However, the mechanical strength of pure aluminium, and the difficulties involved in making low resistance pressure joints have retarded its adoption. This article describes the development of an alloy with a mechanical strength approximating that of copper, while yet retaining an acceptable conductivity, and also the development of a jointing compound which can be used by semi-skilled operators to give stable low resistance joints.

Aluminium has been used as a busbar material for upwards of 50 years, but post-war economic trends have stimulated interest in a more extensive substitution of aluminium for copper. Despite the lower conductivity of aluminium, a weight saving of approximately 57 per cent. can be achieved and, consequently, material cost per foot is reduced, handling is facilitated and installation costs also reduced. To quote but one example, an aluminium busbar installation feeding a titanium melting plant is now being erected at an estimated cost which represents a saving of 40 per cent. on that of an all-copper system. Furthermore, the material may be readily extruded into specially shaped sections which would be impossible to produce economically in copper.[1, 2] Fig. 1 is an example.

In view of the obvious advantages of aluminium as a busbar material, it might have been thought that substitution for copper would have proceeded more rapidly than it has, but in fact there have been two aspects which have militated against its general acceptance. First there was the fear that the relatively low tensile strength of aluminium busbars would be insufficient to withstand either the mechanical or the electrical stresses which might be encountered during service life. This fear led to a search for an inherently stronger aluminium alloy having acceptable electrical conductivity. The successful development of such an alloy is described later.

The second difficulty lay in achieving, in aluminium busbar assemblies, stable joints of low resistivity, using a simple, reliable technique. When exposed to atmospheric oxidation, aluminium rapidly develops a film of surface oxide which is hard, adherent and non-conducting, and joints made with mating surfaces covered with this insulating film have an undesirably high electrical resistance. The conventional method of making connections in aluminium busbars consisted of bolting together mating faces which had been scratch-brushed under dry petroleum jelly, the scratch-brushing serving to remove the insulating film, and the grease to inhibit further oxidation.

Long experience indicated that in general this technique afforded satisfactory results, but that electrical efficiency was dependent upon thorough scratch-brushing and adequate tightening of the joints to provide low contact resistance. Both factors are subject to the human element and the degree of scratch-brushing in particular is liable to vary with operator fatigue, so that it is not surprising that occasional joint failures were reported. As a consequence of this and of the low mechanical properties of aluminium, there has been a certain amount of reluctance among electrical engineers to employ aluminium busbars on a large scale. It was apparent, therefore, that in addition to developing a strong busbar alloy, there was a need for a simple and foolproof method of jointing. Such a method involving the use of a chemical jointing compound has now been established, and the work leading to the development of this technique is described in a later section.

* Technical Officers, Research Department, Imperial Chemical Industries Limited, Metals Division.

THE ALLOY

Alloys based on the aluminium-magnesium-silicon ternary system are extremely versatile in that a whole range of properties may be developed by suitable control of composition and heat treatment. Typical mechanical properties of alloys containing 0·15 to 0·5 per cent. magnesium and 0·15 to 0·5 per cent. silicon are shown in Fig. 2, from which it will be evident that an ultimate tensile strength of about 17 tons per sq. in. may be developed for the highest alloy of this range in the fully heat-treated condition. Such a figure is of the same order as that of copper busbar and compares very favourably with the value of 4 tons per sq. in., typical of pure aluminium extrusions. The conductivity of these alloys is, however, lower than that of electrical grade aluminium and varies considerably with composition and heat treatment.

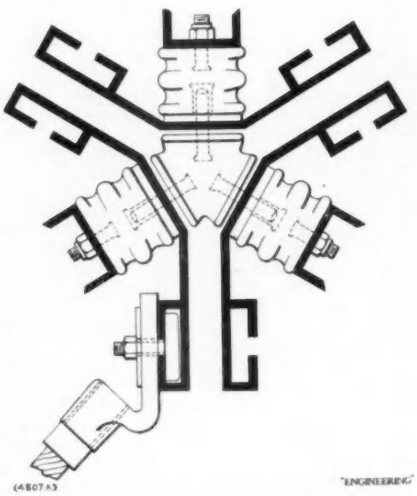

Fig. 1 Aluminium is both cheaper and lighter than copper and can be extruded in complicated section as this rising main shows

In general, after quenching from a temperature in the region of 500 deg. C., electrical conductivity progressively increases with time and temperature of subsequent ageing, while strength increases to a maximum for a particularly critical set of conditions and then decreases. This relationship is illustrated in Fig. 3 for a 0·5 per cent. silicon 0·5 per cent. magnesium alloy solution treated at 520 deg. C. and quenched and aged at 190 deg. C. for periods up to 12 hours, strength being indicated by hardness measurements and conductivity as a percentage of the International Annealed Copper Standard. There is one further factor to be considered, namely the influence of minor impurities such as manganese, titanium, chromium and vanadium, which are often present in commercial purity aluminium alloys and have a most deleterious effect on conductivity, as illustrated in Fig. 4. The solubility of such elements is, however, small and may be decreased by small additions of boron during melting, which react to form insoluble borides with a consequent improvement in conductivity.

Taking these various factors into account, an alloy known as Kynal M38, based on the aluminium-magnesium-silicon system, has been developed having the following properties: U.T.S. 13·0 tons per sq. in.; 0·1 per cent. proof

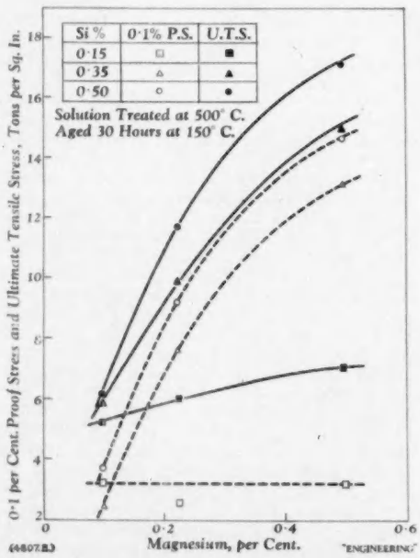

Fig. 2 Influence of composition on the tensile properties of aluminium-magnesium-silicon alloys.

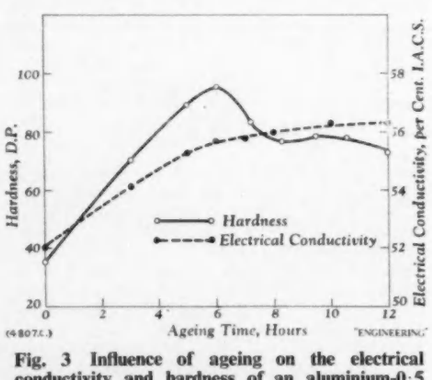

Fig. 3 Influence of ageing on the electrical conductivity and hardness of an aluminium-0·5 magnesium-0·5 silicon alloy, solution treated at 520 deg. C.

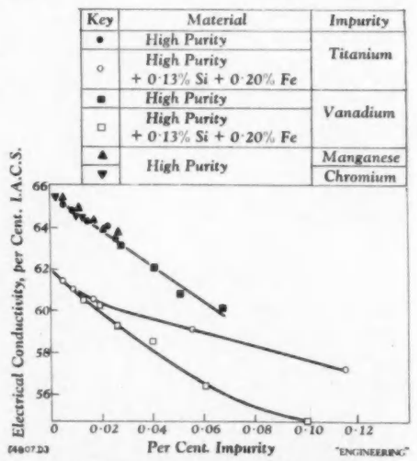

Fig. 4 Influence of some impurities on the electrical conductivity of aluminium.

stress 10·5 tons per sq. in.; elongation 10 per cent; conductivity 55 per cent. I.A.C.S.

JOINTING TECHNIQUE

Numerous methods have been suggested for producing joints of satisfactory electrical properties in aluminium busbar systems, to replace the preparation of the mating surfaces by scratch brushing under petroleum jelly. These methods include tinning, silver plating, or the use of sprayed or rolled-on coatings of zinc, but all involve skilled technicians in time-consuming operations and so add appreciably to the total cost. In addition, the plating techniques are relatively inflexible and demand a considerable amount of prefabrication.

The problem of developing a simple, reliable technique for the preparation of mating surfaces by comparatively unskilled personnel was studied in the research laboratories of Imperial Chemical Industries Limited, Metals Division, and it was decided that a chemical treatment was likely to provide a satisfactory answer for preparation under field conditions. It was appreciated that a prime requirement would be ability to dissolve or disrupt the aluminium oxide film, but it was also essential that some protection should be given to the cleaned surface to restrict re-oxidation, either by deposition of another metal by chemical displacement, or by incorporating oils or similar substances in the chemical mixture.

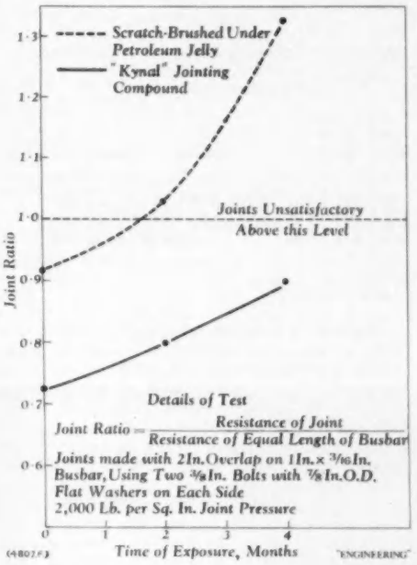
Scratch-Brushed Under Petroleum Jelly
"Kynal" Jointing Compound
Joints Unsatisfactory Above this Level
Joint Ratio
Details of Test
Joint Ratio = Resistance of Joint / Resistance of Equal Length of Busbar
Joints made with 2 In. Overlap on 1 In. × 3/16 In. Busbar, Using Two 3/8 In. Bolts with 7/8 In. O.D. Flat Washers on Each Side
2,000 Lb. per Sq. In. Joint Pressure
Time of Exposure, Months
(4807-E)
"ENGINEERING"

Fig. 6 Effect of salt spray on aluminium/aluminium connections.

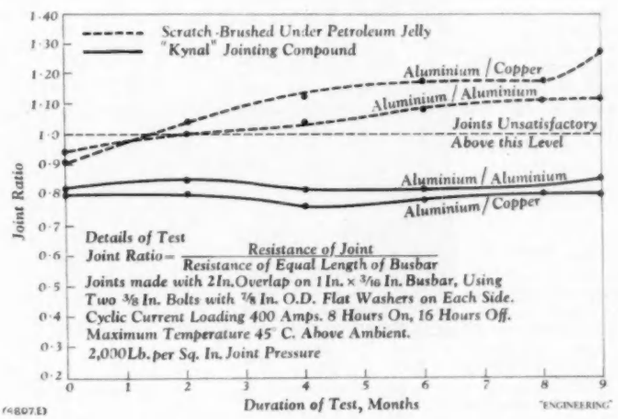
Scratch-Brushed Under Petroleum Jelly
"Kynal" Jointing Compound
Aluminium / Copper
Aluminium / Aluminium
Joints Unsatisfactory Above this Level
Aluminium / Aluminium
Aluminium / Copper
Joint Ratio
Details of Test
Joint Ratio = Resistance of Joint / Resistance of Equal Length of Busbar
Joints made with 2 In. Overlap on 1 In. × 3/16 In. Busbar, Using Two 3/8 In. Bolts with 7/8 In. O.D. Flat Washers on Each Side.
Cyclic Current Loading 400 Amps. 8 Hours On, 16 Hours Off.
Maximum Temperature 45° C. Above Ambient.
2,000 Lb. per Sq. In. Joint Pressure
Duration of Test, Months
(4807-E)
"ENGINEERING"

Fig. 5 Effect of heavy current cyclic loading on aluminium/aluminium and aluminium/copper connections.

In the first instance, experimental joints were constructed after treatment of aluminium busbars with aqueous solutions of ammonium fluoborate. Standard experimental joints of the stepped lap type, with a 2 in. overlap secured by two $\frac{3}{8}$ in. diameter Whitworth bolts spaced 1 in. apart, were constructed from 1 × $\frac{3}{16}$ in. extruded aluminium strip. Pressure between the aluminium faces was controlled at 2,200 lb. per sq. in. by the application of a standard bolt torque of 150 lb.-in. This pressure was chosen since previous work by Melsom and Booth[3] had indicated that a pressure in excess of 2,000 lb. per sq. in. was necessary to ensure low contact resistance. Electrical resistance was indicated by the voltage drop across the joint measured by means of a sensitive potentiometer, and values were expressed as a ratio of joint to busbar resistance, an arbitrary length of 2½ in. being used for both measurements. In general, a ratio of 1 or less was considered to indicate a very satisfactory joint.

Under these conditions of test, a joint ratio of 2·46 was obtained for joints treated with a 20 per cent. solution of ammonium fluoborate, compared with 4·8 for joints assembled without surface preparation. On the other hand, similar joints, in which the mating surfaces were scratch-brushed under petroleum jelly, gave a joint ratio of 0·91. A marked improvement was obtained when a commercial detergent of the polyethylene glycol type was added to the aqueous solution. Thus a joint ratio of 0·83 was obtained, using a 5 per cent. solution of ammonium fluoborate in Lissapol N. A range of concentration of ammonium fluoborate and of hydrofluoric acid was investigated, and the results, recorded in Table I, indicated that a maximum pH value of the order of 4·0 was essential for satisfactory performance. Results for the two fluorides were very similar and it is probable that any fluoride producing an acid reaction in an aqueous solution can be used as the basis of a jointing compound.

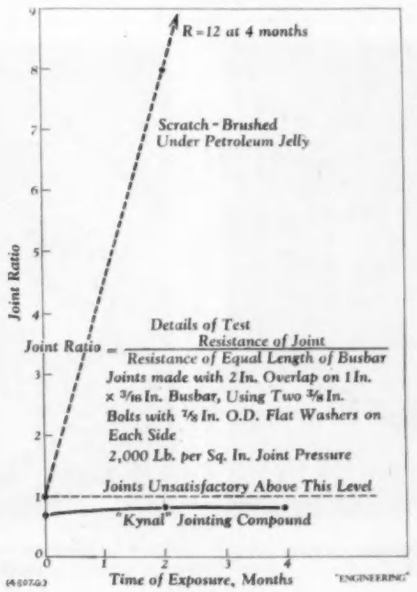
R = 12 at 4 months
Scratch-Brushed Under Petroleum Jelly
Joint Ratio
Details of Test
Joint Ratio = Resistance of Joint / Resistance of Equal Length of Busbar
Joints made with 2 In. Overlap on 1 In. × 3/16 In. Busbar, Using Two 3/8 In. Bolts with 7/8 In. O.D. Flat Washers on Each Side
2,000 Lb. per Sq. In. Joint Pressure
Joints Unsatisfactory Above This Level
"Kynal" Jointing Compound
Time of Exposure, Months
(4807-G)
"ENGINEERING"

Fig. 7 (below) Effect of salt spray on aluminium/copper connections.

TABLE I.—*Effect upon Joint Ratio of Concentration of Fluorides in Lissapol N.*

Fluoride source	Per cent.	pH	Joint ratio
Ammonium fluoborate	0·02	8·3	18·00
.. ..	0·1	8·1	3·60
.. ..	0·5	7·3	3·30
.. ..	2·0	4·8	1·20
.. ..	5·0	4·0	0·83
.. ..	10	3·2	0·80
.. ..	15	2·7	0·76
.. ..	20	2·6	0·79
Hydrofluoric acid(40 per cent. W/W)	0·01	8·2	7·85
.. ..	0·05	8·1	2·97
.. ..	0·1	4·5	1·28
.. ..	0·3	3·75	0·80
.. ..	1·0	2·1	0·76

At this stage in the investigation, the practical application of the compound was considered, and it was realised that, although an aqueous solution of an acid fluoride would produce joints of satisfactory electrical properties, the solution would be inconvenient to use under field conditions because of the difficulty of ensuring an adequate period of contact with the mating surfaces and because of the possibility of evaporation losses. Tests on the solution indicated that unless an experimental joint was completed within 30 minutes of application, the volume of solution was appreciably reduced by evaporation and the residual film was insufficient to prevent re-oxidation of the aluminium surface with consequent deterioration in the electrical properties of the finished joint.

Attempts were then directed towards emulsifying the active agents with oils and greases to produce a compound in a more convenient form and to provide a protective film on the treated aluminium surface. The emulsions, however, lacked stability and separation of two liquid phases occurred on storage. The effect of agents known to act as stabilisers was examined, and more permanent emulsions were produced by additions of sodium alginate. Further experiments were then made with additions of soaps instead of oils and very stable creams containing aluminium stearate were successfully prepared. Finally, the possibility of using soaps which would deposit a protective metal layer by chemical replacement was examined and a compound prepared containing zinc stearate.

Some typical results of the electrical properties of joints prepared with several experimental compounds after various periods of delay between treating the mating surfaces and completing the joints are given in Table II. It should be noted that with compounds containing zinc stearate, the period of delay can be extended up to 24 hours without appreciable deterioration in joint performance. The addition of stearates to the compound necessitated further modification of composition, since it was found that such compounds were less effective if the fluoride was present as ammonium fluoborate, but were perfectly satisfactory if the fluoride addition was made in the form of fluoboric acid.

The compound chosen as having the optimum properties and subsequently patented and marketed as Kynal jointing compound, contained: Lissapol N 71 per cent by weight; fluoboric acid, 8 per cent.; zinc stearate, 21 per cent. by weight.

TESTS ON JOINTS

Electrical Loading

To assess the behaviour of chemically prepared joints under service conditions, a small experimental assembly consisting of standard joints

Continuing Metals and Materials

TABLE II.—*Effect upon Joint Ratio of Treating Mating Faces with Compound and Delaying Assembly for Various Periods.*

Composition of jointing compound						Period of delay and resulting ratio									
Lissapol N	Ammonium fluoborate	Fluoboric acid	Petroleum jelly	Aluminium stearate	Zinc stearate	Zero time	15 min.	30 min.	1 hour	2 hours	4 hours	6 hours	8 hours	16 hours	24 hours
95	5	—	—	—	—	0·82	0·94	1·02	1·18	2·76	2·95	5·85	—	—	—
32·4	1·6	—	66	—	—	0·80	0·82	0·83	0·84	0·90	1·03	2·6	—	—	—
71	—	8	—	21	—	0·72	0·73	0·74	0·75	0·74	0·74	0·92	1·22	—	—
71	—	8	—	—	21	0·75	0·75	0·76	0·76	0·74	0·77	0·79	0·83	0·86	1·08

Note: Joint ratio = $\frac{\text{Resistance of joint}}{\text{Resistance of an equal length of busbar}}$

made both with jointing compound and by conventional scratch-brushing technique, was connected directly to a 2,000 ampere generator, situated in a normal workshop. The current through the busbars was adjusted to about 400 amp., this being sufficient to produce a temperature rise in the joints of about 45 deg. C. above ambient, and the generator was run for 8 hours a day for a five-day week, thus providing cyclic heating and cooling. Joint resistance ratios were determined after various periods of tests and are shown in Fig. 5.

Over a period of nine months, correctly prepared scratch-brushed joints performed fairly well under these conditions, joint ratios rising from 0·9 to 1·2. Superior results were, however, obtained using Kynal jointing compound, aluminium/aluminium or aluminium/copper connections remaining stable at a joint ratio of approximately 0·85.

A more extensive evaluation was conducted on joints exposed to a mildly corrosive industrial atmosphere with its attendant seasonal variations in temperature and weather conditions. Joints were incorporated in an experimental circuit which was erected on the roof of a three-storey building in Birmingham. The circuit was supplied with 2 volt 50 cycle a.c. power at a maximum stable current of 560 amp., the circuit being so designed that replicate series of joints were also loaded at 280 and 140 amp. respectively. A time switch was incorporated in the circuit giving a cycle of 1 hour on and 1 hour off load. Load cycling and consequent heat cycling were introduced to simulate service conditions and to accelerate joint deterioration due to ingress of moisture following joint relaxation during the cooling cycle. Thermocouples were inserted into representative joints and a record kept of ambient temperature in order to establish whether temperature rises at different levels of electrical loading were within the temperature limits specified by BS. 159 : 1932. Measurements of joint resistance were made at intervals over 16 months and are given in Table III.

Fluctuating weather conditions resulted in a wide variation in temperature rise of the joints above ambient, a minimum of 3 deg. C. being observed in the winter and a maximum of 110 deg. C. in the summer. For most of the year, however, the temperature rise for joints carrying 560 amp. was grossly in excess of the 50 deg. C. permitted by BS. 159: 1932. With a loading of 280 amp., temperature rise above ambient was generally of the order of 25 deg. C. and never exceeded 29 deg. C., while the rise for joints carrying 140 amp. was never greater than 9 deg. C.

At the highest current loading, joint ratios for aluminium/copper scratch-brushed joints increased progressively, indicating deterioration and at the end of four months, measurements were discontinued. On the other hand, similar joints prepared with Kynal jointing compound remained at a satisfactory low joint ratio throughout the 16 months' period of test. Aluminium/aluminium joints at all levels of current loading and aluminium/copper joints at 280 and 140 amp. remained at a satisfactory low joint ratio over the 16 months' period of test when prepared either by perfect scratch-brushing or by Kynal jointing compound.

Accelerated Corrosion Tests

Busbar installations are not normally exposed to severe corrosive environments, except perhaps in chemical plants, but if corrosion does occur, it may be accompanied by rapid deterioration in electrical properties. Accelerated corrosion tests were therefore carried out on experimental joints in a salt spray cabinet in order to provide data on performance under extremely adverse conditions, using not only aluminium/aluminium connections, but also aluminium/copper joints for which the corrosion hazard is more marked. Periodic measurements of joint ratio over a period of four months are illustrated graphically in Figs. 6 and 7.

With aluminium/aluminium assemblies, the initial ratio was below unity for both methods of preparation, but fairly rapid deterioration occurred in joints prepared by scratch-brushing, ratios increasing above 1 after about 1 to 2 months' exposure. On the other hand, the joints prepared with the compound had an initial ratio of a very low order, namely 0·72, which increased to only 0·9 after four months' exposure to salt spray. With aluminium/copper assemblies the difference in behaviour between joints prepared by the two methods was much more marked because of the increased susceptibility to corrosion of these bi-metallic connections. Thus the electrical ratio of joints prepared by scratch-brushing was never less than 1, and increased rapidly to a value of 12 after four months' exposure, indicating substantial breakdown of electrical contact between the mating surfaces. By contrast the ratio of joints made with the compound remained stable below unity for the period of test.

It should be emphasised that the extremely

TABLE III.—*Performance of Joints Exposed to Industrial Atmosphere at Various Current Loadings.*

Loading	Type of joint	Preparation	Joint ratios					
			0	1 month	2 months	4 months	8 months	16 months
560 amp.	Aluminium/copper	Scratch-brushed	0·79	0·90	0·95	3·90	—	—
		Jointing compound	0·77	0·74	0·70	0·74	0·76	0·78
	Aluminium/aluminium	Scratch-brushed	1·05	1·10	1·07	1·05	1·07	1·07
		Jointing compound	0·80	0·84	0·79	0·82	0·77	0·83
280 amp.	Aluminium/copper	Scratch-brushed	0·83	0·86	0·86	0·85	0·91	0·85
		Jointing compound	0·83	0·84	0·82	0·86	0·86	0·82
	Aluminium/aluminium	Scratch-brushed	0·90	0·95	0·90	0·90	0·90	0·94
		Jointing compound	0·85	0·75	0·80	0·80	0·85	0·87
140 amp.	Aluminium/copper	Scratch-brushed	0·78	0·83	0·75	0·87	0·83	0·84
		Jointing compound	0·80	0·86	0·86	0·84	0·80	0·88
	Aluminium/aluminium	Scratch-brushed	0·90	0·87	0·90	0·84	0·93	1·05
		Jointing compound	0·80	0·79	0·86	0·80	0·80	0·89

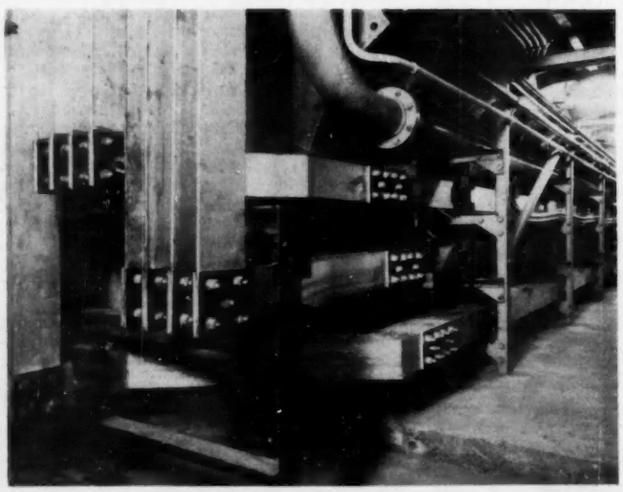

Fig. 8 Aluminium busbar system feeding a titanium melting plant. (Busbars 6 in. by ⅜ in.)

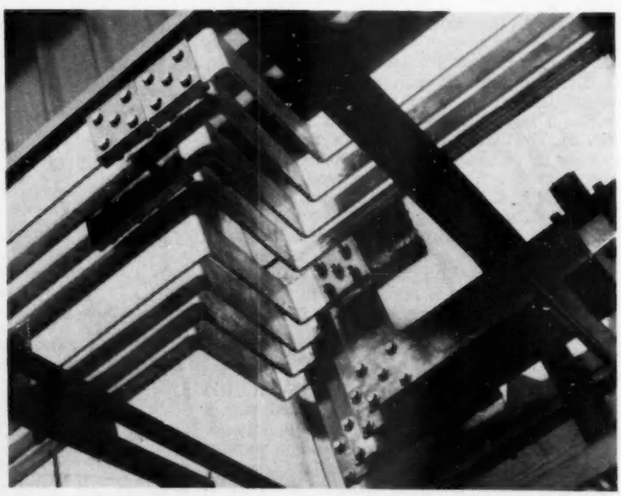

Fig. 9 Aluminium/copper connections in busbar system feeding a titanium melting plant. (Busbars 6 in. by ⅜ in.)

arduous test conditions employed would never be encountered in the life of a normal busbar installation. The sole purpose of the tests was to simulate, in a short space of time, the probable effects of exposure to outdoor atmospheres or proximity to plating shop equipment and the like over a period of many years.

Short-Circuit Tests

Short-circuit tests were made in the Nelson high power laboratory at the Stafford works of the English Electric Company, to whom we are indebted for permission to publish the results. Two lengths of busbar were prepared, each containing two aluminium/copper and three aluminium/aluminium joints, Kynal jointing compound being used to prepare the connections in every instance. A 4 by ¼ in. busbar was used throughout and joints consisted of a 4 in. overlap secured by four symmetrical ½ in. high-tensile B.S.F. nuts and bolts. Belleville spring washers were used in addition to large flat washers with each bolt and, during tightening, pressure was judged to be sufficient when the spring washers were completely flattened. The completed bars were subjected to heavy alternating currents of short duration, representing the maximum through fault-current conditions as laid down in B.S.116:1952, for a system with a symmetrical fault current of 30·6 kA three second duration, and 40 kA one second duration. The resistance of each joint was measured before and after the through current tests and the results are presented in Table IV.

TABLE IV.—*Short-Circuit Tests on Joints Prepared with Kynal Jointing Compound.*

Busbar identification	Short-circuit conditions	Joint No.	Type of joint	Joint resistance (microhms)	
				Before test	After test
No. 1 busbar	10,000 amps. for 3 sec. followed by 16,000 amp. for 3 sec. followed by 22,000 amp. for 3 sec. and 30,600 amp. for 3 sec.	1	Cu/Al	6	12
		2	Al/Al	4	4
		3	Al/Al	5	5·75
		4	Al/Al	5	4·70
		5	Al/Cu	5·5	7·3
No. 2 busbar	20,000 amp. for 3 sec. followed by 30,600 amp. for 3 sec. followed by 40,000 amp. for 1 sec.	6	Cu/Al	4	3·7
		7	Al/Al	5	6·5
		8	Al/Al	5	5
		9	Al/Al	7	7·5
		10	Al/Cu	3·5	4

During tests, the electro-magnetic forces were such as to produce bending and tensile forces in the aluminium. The supporting of the busbar was purposely limited to give a higher value of mechanical strain than would be expected in service and, as a result, appreciable permanent set in the bars was obtained together with a small angular movement at one of the bolted joints. During tests no generally excessive heating occurred at any of the joints, but some increase in joint resistance was observed on certain of them. Subsequent measurement, however, indicated that the doubtful joints had been subjected to lower bolt torque than the more satisfactory ones and when the bolt torque was increased, the resistance was restored to a value approaching the original figure.

These tests indicated that a busbar assembly of this type with a normal current rating of 800 amp. would withstand a three-second duration current of approximately 40 times normal current rating, provided that the bolts were tightened down to a torque of about 65 lb.-ft., corresponding to an average interface pressure of 2,500 lb. per sq. in. The peak currents equivalent to a symmetrical fault current of 40,000 amp., gave no trouble, neither did a one-second through current of 40,000 amp. symmetrical. These results were entirely satisfactory.

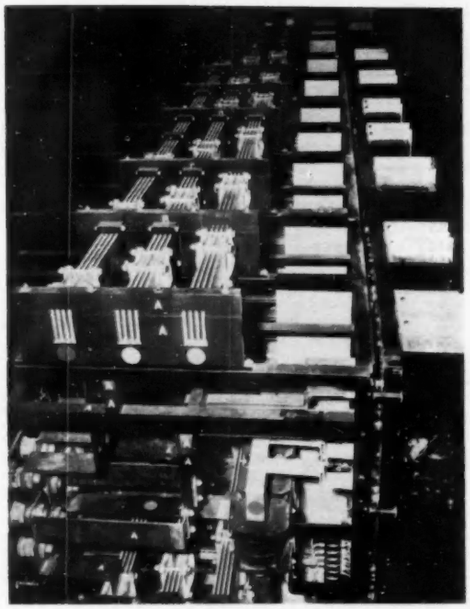

Fig. 10 (left) Flat-back a.c. switchboard with aluminium alloy busbars treated with Kynal jointing compound.

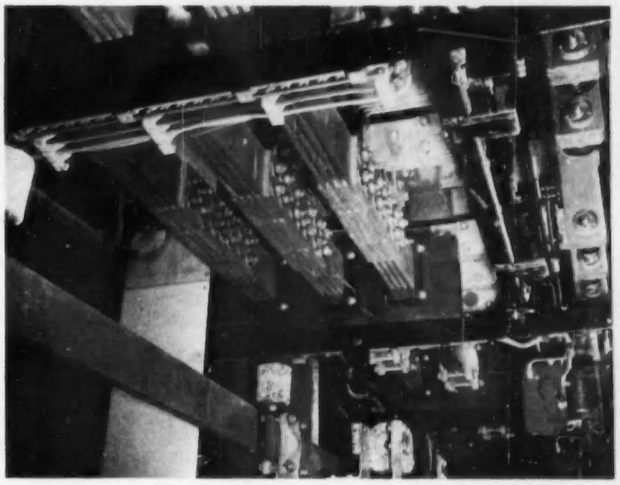

Fig. 11 (right) Typical joints in the system shown in Fig. 10.

Alloy Busbars

The use of the jointing compound in conjunction with alloy busbars has been investigated, and the results presented in Table V indicate that the behaviour of joints varies with the heat-treatment of the alloy. Sections which have been solution heat-treated in an air furnace or salt bath develop an oxide coating which is more resistant to attack by the compound than that on pure aluminium, and joint ratios are rather higher than normal. If, however, the extrusion process is controlled in such a manner that the section leaves the die at the solution treatment temperature and is immediately quenched, a separate solution treatment is unnecessary and the growth of oxide is minimised. Such a treatment has been standardised for Kynal M38, and joint ratios comparable with those obtaining for pure aluminium can be assured.

TABLE V.—*The Use of Jointing Compound with Kynal M.38.*

Heat treatment	Ratio		
	Initial	After 6 weeks indoors	After 4 weeks salt spray
Air furnace	1·40	1·31	—
Salt bath	1·04 / 1·12	1·30	0·94
Quenched at press	0·90	0·95	—

RECENT INSTALLATIONS

Aluminium busbars were selected to carry current to the melting furnaces of the first commercial titanium melting plant to be erected in Great Britain. Flat 4 by ¼ in. extruded strip in commercially pure aluminium was employed, each bar carrying a current of 1,000 amp. d.c. All connections were prepared with Kynal jointing compound, the work being executed by electrical contractors without close supervision. Most connections were aluminium to aluminium, although some aluminium/copper busbar joints, and connections to copper terminals and bars on switchgear, rectifiers and the like were included.

Approximately 6,000 sq. in. of joint face were treated at a cost of one penny for every 70 sq. in. of treated surface. Most of the joints were located in a roofed building in a clean, dry atmosphere but some were situated outside the building and exposed to the weather. Initial joint ratios were in the range 0·60 to 0·75 and these values have remained stable over a period of 3½ years. There has been no deterioration of even unprotected aluminium/copper joints exposed to the mildly aggressive industrial atmosphere outside the building.

This encouraging experience led to the adoption of aluminium busbars for a second titanium melting plant. In this, 8¾ tons of commercially pure 6 by ¾ in. flat aluminium extruded strip were used, aluminium/aluminium and aluminium/copper connections being again assembled using a total of 12 gallons of compound. Some impressions of this installation, which has so far given 18 months' satisfactory service, may be gained from Figs. 8 and 9. Again further extensions to the plant are being erected which will include 30 tons of flat extruded 10 by ½ in. aluminium strip and some 50 gallons of Kynal jointing compound. An estimated cost breakdown for this installation is given in Table VI, from which it is evident that a saving of 40 per cent. on capital cost over that of a corresponding copper system is expected.

TABLE VI.—*Comparison Between Copper and Aluminium for Titanium Melting Plant Busbar Installation.*

	Copper	Aluminium
Size of busbar	8 in. by ⅜ in.	10 in. by ½ in.
Total weight	60 ton	30 ton
Cost of material*	£21,800	£9,000
Cost of compound	—	£200
Cost of installation	£23,200	£17,800
Total cost	£45,000	£27,000
Saving	—	£18,000

* Based on copper at £250 per ton and aluminium at £197 per ton.

A recent example of the use of aluminium-magnesium-silicon alloy busbar in conjunction with Kynal jointing compound is illustrated in Figs. 10 and 11. The installation consisted of a flat-back switchboard designed to feed three-phase a.c. at 440 volts to the ancillary equipment of a continuous galvanising plant in a South Wales steelworks. The busbar system was con-

Continuing Metals and Materials

structed from 4 by ¼ in. flat extruded bar, four bars to each phase, and was largely prefabricated in the manufacturers works. Final jointing, however, between bars and associated risers was effected on site. In the restricted space available, it would have been extremely difficult to scratch-brush the mating surfaces, but stable connections of low resistance were readily prepared using jointing compound.

Kynal M38 conductor alloy and jointing compound have also been selected for a new turbo-alternator load testing plant to be erected in Northern Ireland. The system can be divided into two sections, namely the busbars inside the factory building connecting the alternator under test to a link room, and the busbars from the link room to transformers and reactors located just outside the building. The internally situated busbars will comprise two 10 by 3½ in. channels (BS. 1161 : B.SAC20) located toe-to-toe for each of the three phases, and will be designed initially for 22 kV and 8,000 amp., but with provision for doubling this capacity later. In all, some three tons of this section will be required. The busbars will be mounted vertically, as illustrated in Fig. 12, and supported by ceramic insulators and cast aluminium-alloy clamps. Joints will be made with bolted double fishplates each measuring 10 in. by 7 in. by ½ in., on the web of the sections, mating surfaces being coated with Kynal jointing compound.

Each busbar will be completely enclosed in a duct consisting of a framework of aluminium alloy angles and channels clad with conductor alloy plate. Besides forming a safety housing for the busbars, the duct will minimise or eliminate heating of the adjacent steelwork of the building through induced current effects. The magnitude of the induced currents in the ducting will be of the order of several hundred amperes although at a low current density. It is therefore essential that all joints in the duct should be electrically efficient, and Kynal jointing compound will be applied to all mating surfaces before assembly. External busbars will carry currents of reduced amperage compared with the internal busbars, but at the same voltage. The external assembly will consist of extruded conductor alloy bars of various sections, connections again being effected with the compound.

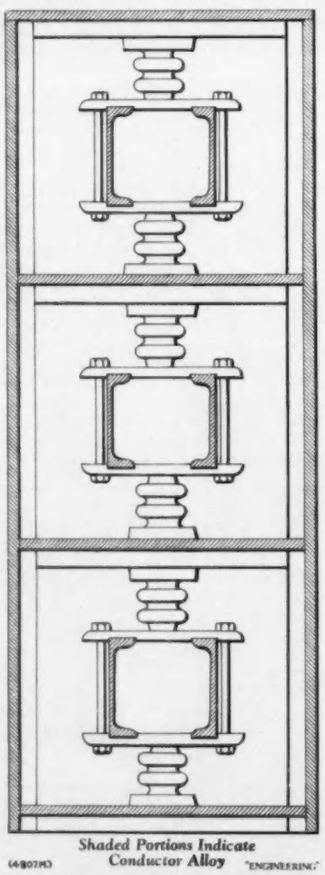

Fig. 12 Arrangement of aluminium alloy busbars in duct with conductor alloy casing to prevent induced currents in the building structure.

ACKNOWLEDGMENTS

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FUTURE TRENDS IN FOUNDING

It seems likely that the present shortage of skilled moulders in foundries will become aggravated in the future, and it will become increasingly important that their efforts should be utilised to the best advantage. This, together with the general tendency towards mass production, will result in a steady extension of mechanisation in the foundry, such mechanisation taking three forms. In the first place, equipment such as moulding machines, at present worked by semi-skilled labour, will tend to become fully automatic. Secondly, machines which operate independently at present will tend to be linked, and, thirdly, power aids will be provided for tasks still requiring manual skill. The above are some of the conclusions arrived at by Mr. J. L. Rice, Mr. R. W. Ruddle and Mr. P. A. Russell in their paper, "Recent Developments in the manufacture of Castings," presented before the Institution of Mechanical Engineers, London, on November 29.

The authors go on to say that the need to economise in skilled labour is likely to promote the use of die casting as opposed to sand casting, especially in the case of alloys of high melting point which are not die-cast extensively at present. Moreover, simplification of casting design and the increased use of work study must ensure that the skilled man devotes the whole of his time to work in which his capabilities are fully utilised, with commensurate financial reward.

Despite the advent of mechanisation and automation in repetition founding, the jobbing foundries will nevertheless still have a large part to play and will require to back the manual dexterity of their skilled craftsmen by an adequate standard of technical and scientific training and by the provision of power aids and other mechanical devices. The jobbing foundries, the authors consider, have so far lagged behind in the latter respect and great scope exists for the increased use of overhead sand supply to a small number of moulding points served by simpler versions of the sand slinger, and for conveyors to take the finished moulds to the casting line.

It is reasonable to expect that an expansion of central technical planning in the foundry will take place to ensure that less is left to the whim of the individual moulder in the matter of gating, feeding, and other aspects of moulding practice. These subjects, the authors believe, will come increasingly under the control of qualified technologists responsible for ensuring that the results of research on such subjects are speedily adopted.

A final conclusion is that electric power for melting is becoming increasingly attractive economically, compared with other fuels, and it is probable that the economic balance will be increasingly in favour of electric melting if the hopes pinned on the development of atomic energy are fulfilled.

WORLD TITANIUM PRODUCTION

Even though titanium is estimated to be the ninth most abundant metal in the earth's crust, only two titanium minerals, namely ilmenite (an iron titanate) and rutile, which consists of titanium dioxide, are considered to be of economic importance. It is stated in a Mineral Resources Information Circular on developments in the titanium industry during 1956, by Mr. T. H. Janes, issued by the Canadian Department of Mines and Technical Surveys, Ottawa, that deposits of ilmenite in the Allard Lake area in Eastern Quebec are possibly the largest known in the world. Some 150 million tons of the ore, averaging about 35 per cent. of titanium dioxide and 40 per cent. of iron, have been indicated by drilling. The ore as mined is crushed and conveyed by rail and ore boat to Sorel, on the river St. Lawrence. Here the ore is mixed with powdered anthracite and the mixture charged into electric arc furnaces. The resultant products are a high-titania "slag" carrying about 70 per cent. of titanium dioxide and 8-11 per cent. of iron, and a low-sulphur, low-phosphorus iron containing about 2·2 per cent. of carbon. This is further desulphurised in the ladle and charged into open-hearth furnaces or cast into pigs.

The bulk of the titania slag is exported to the United States, there being no commercial production of titanium metal in Canada at the present time.

It is pointed out in the Information Circular that the production of titanium metal during 1956 was still confined to three countries of the world, apart from Russia, particulars regarding which are not available. The United States is by far the world's leading producer, with an output of 14,595 short tons in 1956. Japan and the United Kingdom are the second and third countries, Japan accounting for an estimated output of 2,700 tons and the United Kingdom for 1,700 tons in 1956.

The United States output of 14,595 short tons of titanium sponge in 1956 was produced by five companies, namely, the Dow Chemical Corporation, Midland, Michigan; Cramet Incorporated, Chattanooga, Tennessee; E.I. du Pont de Nemours and Company, Incorporated, Newport, Delaware; The Electro Metallurgical Company, Ashtabula, Ohio; and the Titanium Metals Corporation of America, Henderson, Nevada. The combined annual capacity of these plants, at the end of the present year, according to a United States Government estimate, will be 31,500 tons.

In the United Kingdom, Imperial Chemical Industries Limited make titanium sponge by the reduction of titanium tetrachloride by both magnesium and sodium. The company's plant, at Wilton, North Yorkshire, the Information Circular states, has a capacity of 1,500 tons of titanium sponge a year. The I.C.I. melting and fabrication plant is at Birmingham, and additional fabrication facilities are provided at Waunarlwydd, near Swansea. McKechnie Brothers Limited also produced sponge titanium in England in 1956, while melting and fabrication facilities have been built by William Jessop and Sons, Limited, at Sheffield. The initial melting capacity is given as 350 tons a year. A brief description of this plant which is in the firm's Brightside Works, was given in our columns on page 235 of our issue of August 23, 1957.

Much of the Japanese production of the metal sponge is exported to the United States, the total given for 1956 being 1,750 tons.

Management

FOSTER MOTHER OF INVENTION

Patents in the Pattern of To-day

Ideas are the key to technical growth, and if they are to proliferate, means must be devised whereby the inventor may profit from his talent. Protection of the inventor has long been afforded by the patent system, which gives certain legal rights where a first claim to a manufacture embodying an idea is established through the Patent Office. This service has done much to foster the inventive imagination. In recent years the system has become overloaded by virtue of the vast increases in the number of patent applications to be processed. For this reason the regulations have again been under review, and modifications have now come into force. In view of this development and because many more people are concerned to-day with patents than hitherto, we are publishing below a series of notes and articles in which various aspects of patenting are discussed.

INTRODUCING PATENTS

The field of which patents are a part is generally denoted by the term " Industrial Property," and includes the following three sectors: patents for inventions, registered designs, and registered trade marks.

A " Patent of Invention " is a temporary, qualified and conditional monopoly granted by the Crown to encourage invention for the benefit of the public at large. It is granted for a limited time: for sixteen years in this country, and, in other countries, for periods of a similar extent. It is granted only for manufactures: that is to say, processes and articles capable of industrial exploitation. Such manufactures must be new, that is, not previously used nor described in any previously published document. The continued existence of a patent after it is granted is conditional on the payment of annual fees, and on the owner of the patent either exploiting it himself or being willing to license others to exploit it, that is to say, to make equipment embodying the invention or utilising the inventive process.

A " Registered Design " is a similar type of monopoly granted by the Crown but is of different scope, covering merely a shape or pattern or configuration of a thing as it appeals to the eye. A registered design can cover, for example, a new shape or configuration of a combustion stove or a fountain pen, but it cannot cover the construction of a new shaker-grate or ink-filler device.

A " Registered Trade Mark " is a name or device officially registered which indicates to the public the association of a particular manufacturer or trader with a particular article or range of articles.

PATENT DELAYS

There is a complaint that many American and Canadian patent applications are taking from 3½ to 4 years to be accepted, and British applications 2½ to 3 years. This state of affairs seems likely to represent a serious hamper to progress. Development of a new idea may be delayed until those responsible for financing the idea can learn where they stand with regard both to the outcome of the application, and to any applications that may be filed by rival manufacturers.

First, it may be reasonable to consider the case of an application prior to 1939. Under the terms of the Patents and Designs Acts 1907–1938, an application for patent had to be in order for acceptance within 18 months from the date of filing of the original application, or provided extension fees were paid, within 21 months. Unless placed in order for acceptance within the 21 months period, the application was officially deemed to be void, unless an appeal was pending or the time for making an appeal had not expired.

In war time these limits could not be maintained, and under War Emergency Regulations the Comptroller General of Patents was empowered to grant extensions of time. Such extensions enabled Examiners at the Patent Office to complete their investigation covering a 50 year period as to novelty of the invention and also to give the applicant and his patent agent time to consider and deal with the examiner's report and objections. Thus before the war it was possible that when a complete specification was filed at or near the end of the 12 month period which followed the provisional specification accompanying the original application for patent, this same complete specification was examined by the Patent Office and accepted within six months from the filing of the complete specification, owing to the fact that the Statutory period of acceptance was 18 months from the date of the application for patent.

Under present conditions which have prevailed since the war, the result of the official examination on a complete specification never, or hardly ever, is issued before 12 months from the date of filing of the complete specification, and sometimes takes as long as 18 months or more. The reasons for this may be stated to be due to depleted staff at the Patent Office, difficult working conditions at the end of the war, resulting in considerable arrears, and the burst of renewed commercial and industrial development which accompanied reversion to normal trading. As an indication of the work involved, the average annual number of patent applications filed in the 10 year period immediately following the war was 34,769.

However, these reasons should not be acceptable 12 years after the end of the war. Arrears of work and immediate post-war pressure might have been met by an increase in the number of Patent Office examiners. But in addition to the difficult conditions already mentioned, post-war inventions have tended to be more complex, and the accumulation of inventions necessarily increases the time required for a search. Research and development encouraged by the Government has continued, and is to some extent responsible for the inability to revert to pre-war conditions. Thus the time for patent examination has, in fact, remained static.

In order to bring the acceptance time of applications into line with conditions prevailing, a new Act, the Patents Act, 1957, and accompanying regulations, the Patents (Amendment) Rules, 1957, came into operation on April 21, 1957. The new Rules prescribe that the time for putting an application for patent in order for acceptance is to be 3½ years from the date of filing of a complete specification. Thus it is possible for an application for patent to be pending for 4½ years when a complete specification is filed 12 months after the original application for patent.

Such legislation may well be a backward step, and a solution might involve the following. Firstly, the Patent Office should be provided with a far greater number of examiners. The urgency of providing Patent Office examiners might reasonably be thought to be of equal importance to the urgency of providing technical teachers, since the more people who become scientists and engineers, the more inventions will be submitted. Secondly, suitable persons should be encouraged to enter the profession of patent agency, which is believed by many to be greatly understaffed, perhaps partly due to the difficulty of qualification. Again, patent agency as a career is practically unheard of in the universities, and no serious attempt has been made to inform the public in general and technical men in particular, of the opportunities which exist for well qualified scientists and engineers in this profession. If sufficient men of suitable ability are to be recruited into the profession, an attempt will have to be made by Patent Agents to dispel the idea which many industrial and academic scientists have that patent work is a kind of glorified technical report writing which can be left to third-rate scientists, and replace it with a proper understanding of the nature and importance of the work involved. There are signs that this is being done. In other countries such as the United States and Germany there is a much wider appreciation of the work both of Patent Office examiners and of patent attorneys. The third suggestion is that for simple inventions a form of Petty Patent might be granted with or without a shortened form of investigation and having a limited form of monopoly, as in Germany.

Already the Board of Trade recognise the need to increase the staff of the Patent Office, and vigorous attempts are being made to bring this about. But the same is not true of the profession as a whole, where a great deal remains to be done by way of recruitment. It may be that the bottleneck in the next few years with regard to the prosecution of patent applications will be in patent agency work and not in the Patent Office. Indeed, an improvement in the operation of the patent profession may help solve the problem of strain in the Patent Office.

PATENT PROGRESS

The Federation of British Industries stated in a recent annual report that they and others were consulted by the Board of Trade in 1955 about the length of time elapsing between the application and sealing of a patent. The Federation replied that the only real solution was the recruitment of more staff by the Patent Office. Publication should take place after 2½ years, which would stimulate the patentee to prosecute his patent actively. Any new legislation should be flexible so that a period as short as circumstances allowed could be fixed from time to time. The Board did not adopt the Federation's suggestion about publication because it would have meant more work for an already insufficient staff, but on other points the recent Patents Act followed the F.B.I.'s suggestions; and to assist in recruiting staff a new pay scale was introduced. In this as in all other matters affecting both patents and trade marks the Federation co-operated closely with the Trade Marks, Patents and Designs Federation.

PATENTS IN AMERICA

Patent laws in the United States and their administration by the United States Patent Office and the courts are, like the corresponding British institutions, in course of review. A series of reports have been examined by the Senate Judiciary Subcommittee on Patents, Trademarks and Copyrights.

According to *Business Week*, one such report was prepared by Dr. Vannevar Bush, who made the following proposals. More funds, he said, should be set aside to give the United States Patent Office the trained manpower and mechanical and electronic equipment required for document searches. (There are said to be some seven millions of these documents.) Such equipment might also be used to handle technical and trade journal literature in addition to published patents, and according to Dr. Bush,

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computers would reduce the tendency for earlier patents to be overlooked in a patent search. As a result of such oversights, patents already issued sometimes have to be withdrawn, often causing serious inconvenience, if not hardship.

Next, Dr. Bush recommended that the United States Patent Office, before taking final action on a patent application, should provide a period for possible objections and for the presentation of overlooked facts bearing on the validity of the proposed patent. It would thus be necessary to publish a general description of the patent before acceptance. He also suggested that the United States Congress should establish more specific and restrictive criteria for determining whether an invention is suitable for patenting; applications should only be permitted where protection is necessary to bring a useful invention into production. Another proposal is that special tribunals be set up in the United States Department of Commerce to rule on the scientific facts in patents under litigation, and that the findings of such hearings be binding on the courts.

Finally, Dr. Bush recommended that compulsory licensing at a reasonable royalty be required, but only in cases where (1) restrictive patent pools result in domination of an industry, (2) entry into an industry is denied through patent control perpetuated by improvement patents, (3) anti-trust laws are violated, or (4) patents are unreasonably suppressed.

Two other reports were mentioned in the *Business Week* article. One was a review by an attorney, Mr. George E. Frost, of the patent system in terms of its function and operation in the present-day economy. The other was a full statistical analysis by the United States Patent Office of ownership of patents issued since 1939, and included a study of the patents issued to 176 large corporations. It showed that corporations owned 59 per cent. of all patents taken out during the 16 year period surveyed. Mr. Frost's report, which was said to reflect the dominant view of the patent bar, generally defends the present system.

THE WORK OF A PATENT AGENT

By a Chartered Patent Agent

Patents for inventions have a long history: the earliest known English patent of invention was granted in 1449 for making coloured glass, and the legality of this kind of temporary monopoly was confirmed by the Statute of Monopolies, 1624.

The profession of Patent Agency, which is probably both the smallest profession in Great Britain and the least known to the public, is itself by no means of recent origin. Ten persons making a business of obtaining patents for inventors were practising in 1848, and the designation " Patent Agent " seems to have been used as far back as 1776. The Chartered Institute of Patent Agents was founded in 1882 and received its Royal Charter in 1891. In 1889 examinations were introduced for the registration of patent agents in order to ensure a high standard of proficiency within the profession, and for many years it has been an offence for a person to practise as a patent agent unless his name is on the *Register*. At present there are some 450 Registered Patent Agents, the great majority of whom are Chartered Patent Agents, that is to say, Fellows of the Chartered Institute: about two-thirds are in private practice and the remainder in the full-time employment of companies.

The nature of a patent agent's work may not be widely known among engineers, and the object of the present article is to give an outline of it.

Evolution of Patent Law and Practice

Although the grant of patents for inventions was well established in England by the end of the 16th Century, there was no significant development in patent law until the Industrial Revolution. Since 1852, when the Patent Office was founded, there has been an accelerating evolution in the law and practice relating to patents, especially to meet the need to avoid the grant of large numbers of worthless patents, to define the precise area of a patentee's monopoly, and to place more fully in the hands of the public the details of working the invention protected by a patent so that anyone may work it after the temporary monopoly has expired. This evolution is represented by the enactment of 20 Patents Acts since 1850, the issue of Patents Rules regulating procedure, and by a steadily increasing body of case law, which is mainly to be found in the *Reports of Patents Cases*, now running to 75 volumes.

While the original purpose of English patents of invention was apparently to protect the importer of a new industry from abroad, a patent grant is now regarded as in the nature of a contract between the Crown and the applicant for the patent, whereby in return for a 16 years' monopoly, the applicant makes a full disclosure of a new, inventive and workable manufacture, which becomes free for anyone to work when the patent runs out. The monopoly, incidentally, confers no right to use the invention, but only a right to prevent anyone else using it.

The Crown places a heavy onus on the applicant to perform his side of the bargain, and if there is anything wrong with his performance the patent granted is invalid, though certain kinds of invalidity are curable. Some of the many possible causes of invalidity are inherent in the invention; for instance the " invention " may have been known or used before, or may be obvious in view of what was known or used before. Others arise in the preparation of the patent specification; for instance the monopoly claimed in the specification may accidentally cover something already known or used, or unworkable modifications, or the monopoly may be claimed in a way to which no sufficiently clear meaning can be given. In their many decisions finding a patent invalid the Courts have given reasons which are often difficult to understand or to reconcile with earlier decisions. The technique of drafting specifications becomes more complex year by year; indeed owing to the doctrines developed in the course of a series of judicial decisions there are some problems of specification drafting, especially in the field of chemical invention, to which no entirely satisfactory solution exists. British Patent Law is still in its infancy and the patent agent finds that he constantly meets with points of law which are unresolved: moreover, many basic principles are not yet settled and are the subject of much controversy.

It is not surprising therefore that only about 2 per cent. of patents are now obtained without the assistance of a patent agent; inventors can deal directly with the Patent Office if they wish, but without expert advice they are more than likely to obtain rights of little value.

Patent Application Procedure

A potential applicant may seek the services of a patent agent specialising in a particular field of invention. Many patent agents specialise in this way, according to the nature of their basic technical training (most patent agents qualifying to-day are graduates). Very often a chemist will by his own choice handle chemical inventions only and an engineer will seldom feel he is adequately equipped to handle a chemical or an electronics invention, not only because its language is unfamiliar to him, but also because different techniques of specification drafting are used in different fields of invention and it is impossible for one patent agent to be proficient in all fields of invention.

When a patent agent is provided with the necessary information on an invention to proceed, he analyses the facts in relation to what is already known (the " prior art ") to find the new principles underlying the invention, so that he can define it in its most basic form. This is one of the most important and difficult operations in all his work. He also formulates a series of definitions of the narrower forms of the invention, ultimately coming down to the individual embodiments which the inventor has provided. He next drafts a specification around these definitions. This usually takes the form of a " provisional specification," and it may go through three or four drafts before it reaches its final form and is " filed " in the Patent Office, thus forming a patent application which is sometimes known as a " provisional patent," though it is in fact not a patent at all. Its purpose is to establish a date of priority for the invention described in it, after which, publication or a later application by someone else has no detrimental effect on the applicant's rights.

The " provisional " lies in the Patent Office until a " complete specification " is filed within a year from the date thus set up. During this year further developments in the invention can take place, and these are incorporated into the " complete " when this is drafted: a critical reassessment of the definitions of the invention is made at this time and in the " complete " is included a set of " claims " corresponding to these definitions, these " claims " setting out the scope of the monopoly desired.

The completed application is in due course examined in the Patent Office by an examiner, who is normally a graduate qualified in the technical field into which the invention falls. The examiner searches British patents and other literature to see if the invention is new and also examines the application for other legal and formal requirements. He sometimes finds a completely anticipating earlier document and when this happens the application has to be abandoned. More often, he finds a partial anticipation, and an amendment limiting the scope of the application to what is new is made by the patent agent. Amendment may be necessary because of a prior unpublished application for the same or partly the same invention by someone else. Sometimes the application has to be " divided " into two or more applications. The application documents pass back and forth between patent agent and examiner until each is satisfied with the application: if they cannot agree there will be a " hearing " before a higher officer of the Patent Office, and if necessary an appeal can be taken to the Patents Appeal Tribunal. This examination stage of the proceedings is often referred to as the " prosecution " of the application.

When the application is in order, it is accepted by the examiner and a printed specification is issued. There then follows a period of three months in which opposition can be lodged on certain specified grounds by other interested parties. If an opponent comes in, then the matter is fought out much in the same way as a case in the law courts, with a senior officer of the Patent Office as the judge. Any opposition disposed of, the patent is finally " sealed," that is, granted. This is usually about 3 years after the " provisional " is filed.

A patent agent may file a complete specification without a provisional; often he files a " complete ", claiming priority under an International Convention from a patent application made up to a year earlier in a foreign country, and such an application is known as a " Convention " application.

Obtaining Foreign Protection

As there is no such thing as a " World Patent," foreign protection has to be obtained by applications made concurrently with the British application in those countries where protection is desired, and this is frequently done by filing

" Convention " applications in these countries. While usually foreign protection is required only in the most important countries, such as the United States, Western Germany and France, sometimes as many as 10 or even 25 countries are involved. The patent agent prosecutes these applications through his foreign associates, for instance a United States patent attorney, and for this purpose he requires a sound knowledge of the patent laws and practices of all the countries of the world, which are very diverse. In some countries, such as Germany and the United States, where the patent system is more highly developed, the procedure is much more complex than in Britain and the examiners have wider powers of rejection. In such countries a grant may sometimes take 5 years to secure, and many applications fail.

The patent agent has to co-ordinate the prosecution of the foreign and British applications as best he can: for instance prior art may be " cited " by an examiner against the German application, of which account needs to be taken elsewhere.

Other Aspects of a Patent Agent's Work

Although a patent agent's work is naturally centred on obtaining patents, his field of activity is very much wider. He frequently has to interpret specifications in order to give advice on whether his client's operations are an infringement of the patents concerned, and if so, whether the patents are valid. He may be required to seek an extension of term of a patent; to conduct opposition proceedings against a patent application; to advise in an infringement action in the High Court; or to sort out problems concerning the ownership of employees' inventions. He may also undertake work on Trade Marks or Designs; a Registered Design is a kind of patent for an ornamental design applied to a manufactured article. If he is a company patent agent, he may be called upon to negotiate agreements with other patentees for patent licences so that a manufacturing project can proceed.

A patent agent's work is one of great variety and intense interest. The knowledge he is required to have for the successful pursuit of his profession is about the broadest required by any profession: he needs a sound grasp of basic scientific principles, detailed knowledge of one of the most difficult branches of law in respect of all countries of the world, and a broad background knowledge of manufactures in all fields; he must also have the ability to write clear English and an understanding of the art of advocacy. By the nature of his work, every task he undertakes presents new problems, and many of them are so profound that if he can give sufficient time to their solution he can obtain great intellectual satisfaction.

PATENTS AS EXPORTS

Attention has been drawn to the value of patents as exports in an article in *The British Manufacturer* by Col. T. W. Vigers. The article states that while immense effort has been and is being devoted to the export of the products of our hands, the export of the product of our brains, in the form of patents on inventions and methods, has been grossly neglected. It is significant that the development and patenting of inventions to put them into marketable form, requires no raw materials, imported or indigenous, but the resulting patents can be sold for lump-sum payments, royalties or both, at highly profitable rates; and these sales represent almost net profit to the seller and to the national economy. One well-known firm is deriving an income of £100,000 a year in royalties under patents in connection with jet engines alone. Many hundreds of other firms hold patents which are highly successful in the home market and could be sold profitably abroad, but lack overseas connections and knowledge of procedure.

The successful exploitation of inventions in overseas countries demands a variety of technical, market, legal and linguistic knowledge and wide connections. The market is almost infinitely variable in that each invention is, as a rule, applicable only in a limited number of countries according to their degrees of industrial and agricultural development, standard of living, resources and climate. A consultant with the necessary knowledge can save the inventor much time and expense by selecting the countries in which patent protection should be applied for, by suggesting appropriate firms to approach with offers of manufacturing and selling licences and by conducting the negotiations in the light of specialised knowledge of local conditions, regulations and languages. This service is highly organised in most other countries, particularly in Germany, with highly profitable results, but is practically non-existent in this country.

Col. Vigers concludes by remarking that the " overseas representatives of the Board of Trade could render valuable help by exploring the market for this neglected export. It is clearly in the national interest to extend the sale of British inventions, as well as British manufactures, abroad; and it is not unreasonable to hope that the Board of Trade and the bodies representative of industry will give the matter that degree of attention warranted by its importance."

PATENT ORGANISATIONS

A number of organisations exist to aid and assist the smooth running of the patent system in Britain.

Patent Office

The Patent Office, which was established by an Act of 1852, is attached to the Industrial Property Department of the Board of Trade, 25 Southampton-buildings, London, W.C.2. It is responsible for the granting of Letters Patent, and for the administration and recording of patents, and holds copies of all United Kingdom and many foreign patent specifications.

The Chartered Institute of Patent Agents

The nature of a patent agent's work is outlined in an earlier article in this series, and the Chartered Institute of Patent Agents is the qualifying body to which most patent agents belong. The Institute was incorporated in 1882 under the Companies Acts of 1862 to 1880. Among the aims included in the Institute's " Memorandum of Association " are the following: to form a representative body of the patent agents of the United Kingdom for the purpose of promoting improvements in the Patent Laws and in the regulations under which they are administered; to frame and establish rules for the observance of patent agents in all matters appertaining to their professional practice; and to provide opportunities for the interchange of ideas and knowledge. The Institute was incorporated by Royal Charter in 1891, and a Supplemental Charter of 1937 specifies classes of members as follows: Fellows, Associates, British Oversea Members, Foreign Members and Honorary Members. All patent agents require to be registered, and qualifying examinations are the responsibility of the Institute. Its address is Staple Inn-buildings, London, W.C.1.

The Institute of Patentees

An organisation set up to guide and assist inventors is the Institute of Patentees (Inc.), the head offices of which are at 207-8 Abbey House, 2-8 Victoria-street, London, S.W.1. The aims and objects of the Institute are stated as follows: to assist and advise inventors in gaining protection for ideas and placing them commercially; to consider, originate, promote and support alterations in, or additions to, the Patent Laws which are in the interests of patentees; to provide a link between inventors and manufacturers; and to obtain wider recognition of the value of invention and, by seeking better facilities, cheaper procedure and lower taxation, to encourage the inventive talent of this country. Membership is not restricted to patentees and inventors, but is open to all wishing to keep abreast of developments in Patent Law, including manufacturers, trade unions and societies. Services include technical and legal advice, commercial assistance, exhibition of inventions, arbitration, information and publication of the *Inventors' Review*.

National Research Development Corporation

The National Research Development Corporation is a public body, set up by Parliament under the Development of Inventions Act, 1948 (clarified and extended by a further Act of 1954) to develop inventions of potential value to the national economy, and to pass them on for commercial exploitation at home or abroad. It is mainly concerned with inventions resulting from public research. Its staff of 105 includes a number of qualified chemists, physicists, engineers and patent agents. The Corporation's business is run with public money but on commercial lines. Over the years it has to balance its expenditure with its income. Within the limits already described, it may invest in research or development or even in production. Experience has shown that an isolated development contract unrelated to sufficient initial orders to prove the market may be inadequate to achieve the Corporation's aims. The Corporation has, therefore, in a limited number of cases, found it essential, with the approval of the Board of Trade, to give the contractor sufficient initial orders to enable him to undertake production. The Corporation usually requires a royalty in the form of a percentage of the selling price of the goods or apparatus embodying the invention. A special case arises with inventions made by Government employees, for the Crown retains the right to benefit by these inventions free of royalty after transfer of the patent rights to the Corporation. A " Free Crown User " clause in the licence agreement provides that no royalty shall be paid by the licensee to the Corporation on articles made under the patent which are supplied to any Government department.

The Corporation's portfolio includes inventions in mechanical and electrical engineering, electronics, scientific instruments, chemical technology and pharmaceutical products. The greater part of these inventions come from Government research establishments and the remainder from such bodies as the Medical Research Council, the Agricultural Research Council, the universities and hospitals. The Corporation is further charged with seeking licensees for certain Canadian inventions under a reciprocal arrangement with Canadian Patents and Development Limited, an agency of the Canadian National Research Council.

The *NRDC Bulletin* is at present published periodically and mailed free of charge on request to approved industrial concerns and to libraries. Inquiries should be addressed to 1 Tilney-street, London, W.1 (telephone: Grosvenor 5431).

Inventions for Industry Limited

There are a number of private organisations prepared to assist inventors who wish to secure patents or to have existing inventions exploited industrially. Only one such body need be mentioned here.

Inventions for Industry Limited has been set up to assist the inventor to place his work and to secure the most advantageous terms. The organisation offers to act as agents for inventors in the placing of their inventions and in negotiating the terms on which the inventions may be developed and marketed. They propose to scrutinise inventions which may be submitted and, where these inventions appear to have industrial applications and are adequately protected, they will approach selected potential users to initiate discussions. While not acting as patent agents, the company will help inventors to secure protection for their inventions. The company, which also offers manufacturers advice about inventors and inventions, does not charge inventors any registration fee, but will normally aim to finance their operations out of an agreed percentage of the payments received by the inventors. Inquiries should be made to 15 Palace Chambers, Bridge-street, London, S.W.1.

Continuing **Management**

Weekly Survey

Canadian Outlook

While the Canadian trade mission continues to generate a good deal of optimism in this country about Anglo-Canadian trade, more warning voices come from Canada about the slowing down in activity over there. The latest comment on this subject comes from the president of the Bank of Montreal. The president of the Bank remains optimistic about the long-term expansion of industrial potential in Canada but he foresees a series of, at times, painful short-term adjustments. He is much more concerned about the dangers of inflation than about the immediate consequences of a measure of deflation. He does not hold the view that inflation is to some extent the price of progress.

The trend is perhaps less under the control of Canada than its Government finds it expedient to admit. No matter what steps are taken to insulate Canada from the United States economy, the behaviour of the latter must continue to have a measure of influence on Canada. Canada is very much dependent on the United States as a market and it is not easy for it to pursue a policy of expansion at a time when there are deflationary forces at work in the United States. If deflation in the United States goes far enough and lasts long enough to affect the level of world commodity prices, as it is doing at the present time, it is well nigh impossible for Canada to go its own way. The Dominion will remain for an indefinite period very much dependent for its prosperity on the level of wheat prices and those of certain of the metals. Canada's very real efforts to develop its overseas markets at the present time and to become less dependent on its southern neighbour are sound but the effect of such a policy, even if it is successful, will be marginal for some time.

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American Research and Development

The surge of anxiety in the United States at the rapid rate of technical development in the U.S.S.R. has not yet been translated into concrete proposals for expansion of United States research and development programmes. Nevertheless, the recent publication *The Federal Research and Development Budget for the Years* 1956, 1957 *and* 1958 shows a very marked expansion in Government expenditures for scientific research and development in the last nine years. From a post-war low of 870 million dols. in 1948, the Government's obligations have expanded to almost 3·2 billion dols. in the fiscal year 1957 and are expected to rise to 3·4 billion dols. in 1958. This represents a rise from a little over 2 per cent. of the national income in 1948 to over 4 per cent. in 1957.

As in this country, defence accounts for a very high proportion, nearly two-thirds, of the total expenditure. The Department of Defence and the Atomic Energy Commission together accounted for 88 per cent. of the total funds in 1956 and will account for about 82 per cent. in 1958. The total commitments of the Defence Department rose by about 10 per cent. between 1956 and 1957 and those of the Atomic Energy Commission by about 60 per cent. These increases were, however, outweighed by an increase of more than 100 per cent. in the commitments of the Department of Health, Education and Welfare.

The most hopeful development for the future, however, is probably the fact that research expenditure by private industry has been expanding even more rapidly than Government expenditure with the result that the latter is estimated to account for only about 30 per cent. of total research expenditure. The rapid advance in expenditure by private industry began in 1953 and more than doubled between 1953 and 1957. There has recently been some criticism of the fact that this expansion has not yet been reflected in a flood of new products but a recent survey of the time factor in research and development showed that some four to six years are required to develop a new product from the idea stage to full-scale production and that at least two more years are required to develop markets. The results of the research boom starting in 1953 will therefore not become apparent before 1960.

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Steel as a Bellwether

Those who are watching the symptoms of industrial recession in the United States pay a good deal of attention to the trend of steel output. The situation in this country might be equally rewarding as a study of economic trends. This year steel deliveries in this country about matched the slight increase in industrial production. This is something of a contrast with 1956 when steel deliveries were noticeably ahead of industrial output. It is tempting to look for reasons why the steel industry is less resilient to the trend of industrial output than a year ago and why it is unlikely to reach a record figure in 1957.

The picture is diverse and on the whole reassuring. The sharp recovery in the motor vehicle industry this year has brought with it a revival in the demand for sheet steel whereas the tinplate outlook is somewhat unsettled. Business in heavy plates is still brisk and there are no signs yet of any severe cut-back in the production of constructional steel as the volume of approved building plans drops off. There have been reports of a considerably easier position in billets for re-rolling. Business in heavy forgings is still good. Alloy steels have felt the impact of the contraction in the aircraft industry but these are as yet a minor proportion of total steel output.

It is difficult to tell from available figures of deliveries and production exactly what is in store for the industry in the next few months. It is possible that the order books are telling a rather less reassuring story than figures of the actual movement of steel. The most doubtful of all is the prospect for constructional steel. The recent reduction in building plans approved is bound to have an effect on the level of constructional steel output by the early months of 1958.

Some sections of the steel industry could take a short-term reduction in orders without any great dislocation, for order books are well over a year for delivery in some cases. Others are less well placed. In a sense, a reduction in steel output is inevitable if the Government pursues a policy of limiting capital development, but once reduction in output has taken place the warning has been given that restriction of expansion has bitten deep into the economic system and that counter measures will have to be taken if long-term plans of expansion, as opposed to short-term cut-backs in output, are not to be jeopardised.

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The Anglo-German Talks

The Anglo-German talks held last week had important implications for British industry as well as the more publicised political aspects concerning NATO. The German Government has reached the point where its guiding hand on the German economy is a trifle less confident and successful than it has been in the past. There are a number of wage demands pending and the prices of basic materials are already moving upwards in response to higher wage rates. The latest reports on the state of orders for German goods are of a 2·3 per cent. increase in the total volume of orders received in October, compared with the same month in 1956, but much of this increase seems to have been for capital investment goods in the German market. Export orders in capital equipment were 14 per cent. down in volume and those for consumer goods were 11 per cent. down. It is not unlikely that this emphasis on capital development in the home market is a sign of Germany's preparations for the European Common Market which now only awaits Dutch ratification.

In the last week the German Government has shown an increasing awareness of its need to offset its large export surplus with some form of foreign investment. The precedent may have been set by a German banking consortium buying Dm 200 million of Belgian treasury bills for a 15 month period. So far as the Free Trade Area is concerned, it is already known that the Germans favour most of the features of the scheme as outlined by the British, and not much progress can be made by any bi-lateral discussions between Britain and Germany. When the time comes to discuss the critical points of a Free Trade Area scheme, it is likely that the European Common Market participants will speak with one voice. The critical talks, so far as Germany is concerned, will therefore be with the French and Belgians.

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What Price the City?

The foreign income of the banks, insurance companies, commodity markets, shipping interests, and the whole variety of financial services provided by the City of London are taken, more or less for granted, as a part of Britain's invisible earnings. But what are all these things worth in hard cash, or better still hard currency? This question has been answered in two different ways on the Third Programme. Mr. Alan Day who is Reader in Economics at London University, suggested that Britain was paying too high a price for the privilege of acting as banker to the sterling area and that the loss from cutting down the international banking business of the City would be negligible. " It is unlikely," he said, " that the net earnings arising from the international financial services provided by London amount to more than £20 million, or at most £30 million a year. . . ." A very different view was taken by Mr. John Wood, an economist, who as a member of the staff of a City merchant bank sees international operations from a less academic standpoint. In his view the City's earnings come to something like £110 million and he went on to show how he arrived at this figure. Insurance is the most important source of " invisible " income, with net foreign exchange earnings of about £40 million a year. The London commodity markets probably earn about £30 million net a year. Commissions on the Baltic Exchange come to about £20 million. Interest and commissions on credit and loans must be allowed for on the estimated £150 million of short-term credits, the £200 million of medium-term export credits, and on the £60 million of permanent capital raised by borrowers outside Britain each year. The fees and commissions on all these items come to about £10 million. Finally, the City's general banking services, the basis on which the whole mechanism depends, bring a further £10 million.

The curious thing about this discussion is not the wide discrepancy between the two sets of estimates, but the fact that the City itself seems content to let its case go by default. No serious effort at calculating the true earnings on foreign balance has been made since before the war. The operations of the City are in any case a mystery to the layman. If expert economists can produce such widely conflicting estimates when the whole future of the sterling area is under discussion, it is high time for the City to reconsider its policy of silence.

Engineering at Home

CASTLES IN THE AIR

An Englishman's home is his castle. At least he would like it so. But many Englishmen would like their castle sited right in the centre of a large city—London for example. Such an arrangement has the advantage that privacy is got without the penalty of isolation. Unfortunately such an arrangement usually involves a castle of the castle-in-the-air variety—built only in the imagination. Coming down to earth, one quickly sees that ground space in cities is limited. As a result, tall blocks of flats form a conspicuous feature of the city skyline. But dwellers in flats, although up in the air, rarely have the privacy of castles.

A block of flats often imparts a feeling of mass living. The occupants find it difficult to identify their own homes as separate entities. In many cases complete isolation is not wanted, but the degree of individuality associated with a semi-detached house is. To introduce this individuality into multi-storey buildings, the architects Drake and Lasdun have developed the cluster block.

Fig. 1 shows a view of a 16-storey cluster block. It is being erected in Bethnal Green by Wates Limited, London-road, S.W.16. Fig. 2 shows a plan of the block. It will be seen that the design is based on an independent central core from which bridges pass on every floor to four maisonette towers. The block is to contain 56 two-bedroom maisonettes and, on the fifth-floor level, eight bed-sitting rooms. Many of the tenants have direct access to their own front door without having to pass any other dwelling.

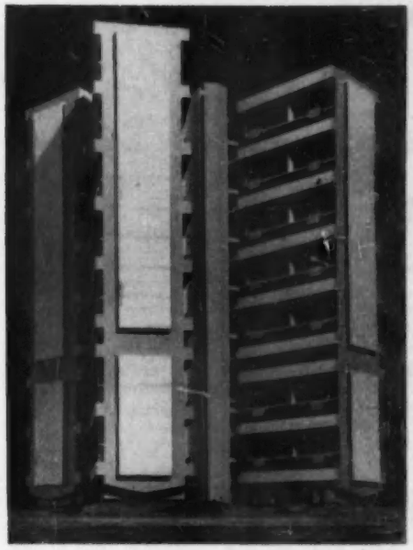


Fig. 1 With only two maisonettes on each floor it is possible for the occupants of the cluster block to escape from the feeling of "mass living" that is often associated with multi-storey flats.

There are two other basic qualities of the design: the local environment penetrates the body of the building and is experienced from within; and the building is better to look at than a single rectangular block, because of the reduction in repetitive content and apparent mass by the creation of recognisable visible groups.

The central core contains the staircase, lifts, refuse chute, and—on every other floor—a drying area. In the towers, two maisonettes occupy each floor. Each has an area of 800 sq. ft. and comprises, on the lower floor, a living room, kitchen (both leading to a private balcony), a hall and pram store, and a w.c. On the upper floor there are two bedrooms, a bathroom, and a box store. Full central heating is provided by individual water heaters.

Piles sunk 30 ft. provide the foundation for the block. The main vertical structure of each tower—two end walls and one party wall—is of reinforced concrete. Timber is used for the intermediate floors in each maisonette. In conjunction with the reinforced structure, precast cladding units of Portland stone finish are used. These are manufactured by the Modular Concrete Company, Limited, Bedfont, Middlesex. About 170 units of different sizes ranging from 3 sq. ft. to 220 sq. ft. are being employed.

The main floor between dwellings is of reinforced concrete. Thus under lateral loading the structural walls act together. For loading in other directions, the bridges joining the towers to the central core transfer the lateral forces to the walls best situated to cope with them. In fact the bridges act as beams in their own planes and as struts or ties. The joining together of the towers in this manner greatly assists the structure to resist the wind, whatever its direction. The actual movement of the composite structure is expected to be about a fortieth of the maximum movement of a single independent tower. The consulting engineers are Ove Arup and Partners, London, W.1.

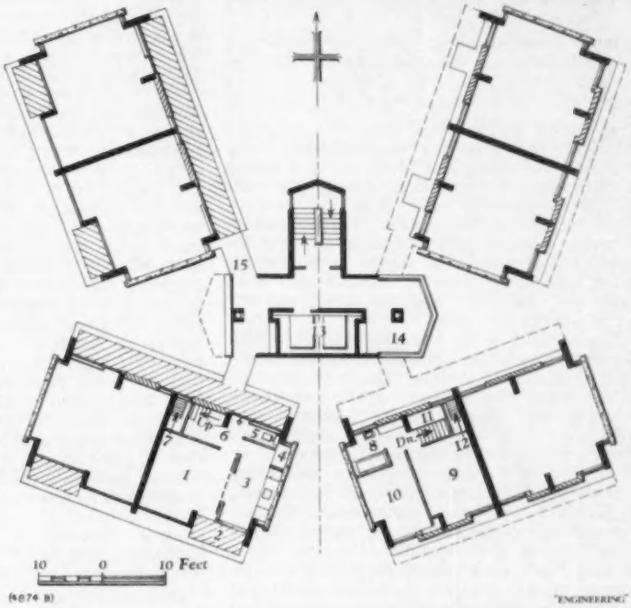


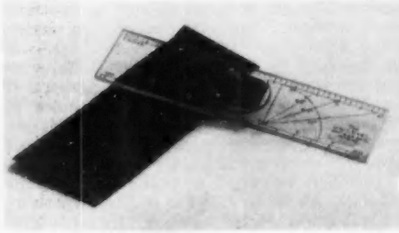
Fig. 2 The plan shows the manner in which the four main towers are sited in relation to each other and to the central core. The towers act together to resist wind loads.

Key: 1 living room, 2 private balcony, 3 dining kitchen, 4 larder, 5 w.c., 6 hall and pram store, 7 escape ladder, 8 bathroom, 9 principal bedroom, 10 second bedroom, 11 box store over stairs, 12 escape ladder, 13 lifts, 14 drying platforms on alternate floors, 15 bridge connections between core and main blocks.

Lower floor: 1–7.
Upper floor: 8–12.

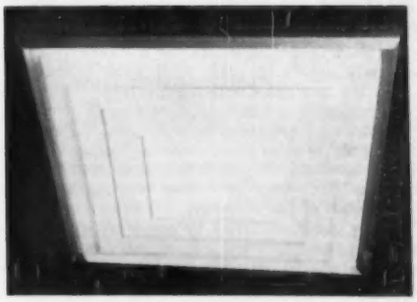
A THREE-WAY LEVEL

A pocket level which is described as being useful for builders, engineers, architects, carpenters and music lovers has been produced by Dorset Light Industries Limited, East-street, Bridport, Dorsetshire. It takes the form of a 6 in. rule in transparent plastics, in the centre of which is mounted the chamber containing the bubble. The chamber has cross-lines moulded upon it and these are true to the edges of the rule. They are also true when the rule is laid flat on a surface, level being indicated by the bubble being on the crossing of the two lines. The level can be used for any normal purpose where a quick check is required of a horizontal or vertical surface and the edges of the rule are calibrated in inches and centimetres. A protractor scale engraved at one point allows the instrument to be used as a clinometer.



TRANSLUCENT PANEL LIGHTING

A module lighting system to give overall illumination or to highlight particular points is now being produced by Lumenated Ceilings Limited, Alliance House, Caxton-street, London, S.W.1. It consists of translucent plastics panels supported in an aluminium framework below the lamp arrangement and forming a false ceiling. It is based on a 2 ft. square module. Two standard types of panel are available, one moulded from vinyl plastics with a decorative face in alternative patterns, and the second moulded from acrylic plastics and completely plain. Symbols, monograms, etc., can be incorporated in the vinyl panels if desired, and these will be available shortly in colour. The panels rest on an aluminium framework suspended from the structural ceiling, and can be lifted out to provide access to the lamps. The aluminium track is an extruded section with a fluted face, and is supplied with the ends ready mitred in standard lengths of 2, 4, 6 and 8 ft. Slide-on clips join the lengths together and the track can be anodised if required. The complete installation weighs approximately 6 oz. per sq. ft.



Book Reviews

MATHEMATICAL EQUIPMENT

Mathematics. By A. T. STARR. *Sir Isaac Pitman and Sons, Limited, Pitman House, Parker-street, Kingsway, London, W.C.*2. (45*s.*)

Engineering Mathematics. By KENNETH S. MILLER. *Constable and Company, Limited,* 10 *Orange-street, London, W.C.*2. (47*s.* 6*d.*)

Numerical Methods in Engineering. By MARIO G. SALVADORI, with problems by MELVIN L. BARON. *Longmans, Green and Company, Limited,* 6 *and* 7 *Clifford-street, London, W.*1. (52*s.* 6*d.*)

The Numerical Solution of Two-Point Boundary Problems in Ordinary Differential Equations. By L. FOX. *Oxford University Press, Amen House, Warwick-square, London, E.C.*4. (60*s.*)

Applied Analysis. By CORNELIUS LANCZOS. *Sir Isaac Pitman and Sons, Limited, Pitman House, Parker-street, Kingsway, London, W.C.*2. (55*s.*)

Vector Analysis. By LOUIS BRAND. *John Wiley and Sons, Incorporated,* 440 *Fourth-avenue, New York* 16, *N.Y., U.S.A.* (6 dols.); and *Chapman and Hall, Limited,* 37 *Essex-street, London, W.C.*2. (48*s.*)

Laplace Transformation: Theory and Engineering Applications. By WILLIAM TYRRELL THOMSON. *Longmans, Green and Company, Limited,* 6 *and* 7 *Clifford-street, London, W.*1. (32*s.* 6*d.*)

These seven mathematical texts, five American and two British, provide a broad indication of the mathematical equipment likely to be required of the present-day engineer. Though the bulk of this necessarily stems from the classical doctrine, the emphasis shifts to meet modern demands, bringing certain branches into prominence at the expense of others, while various newer and more powerful methods that have been, and are still being, developed call for increasing consideration.

The concern of the first two volumes is with the more general but quite indispensable mathematical groundwork. Dr. Starr's *Mathematics* is the latest addition to Pitman's well-known "Engineering Degree Series." It has been written to cover the syllabus of Mathematics Parts I and II for the engineering degree in the University of London—a syllabus sufficiently comprehensive and intelligently enough devised to satisfy the minimum mathematical requirements of most undergraduate engineering courses. Developments in the calculus are carried as far as partial differential equations and other topics treated include complex variables, vector and harmonic analysis, elementary probability and statistics and operational calculus. Two chapters headed "Applied Mathematics" deal with problems in mechanics and hydrostatics. The worked examples and exercises are mainly drawn from past London University examination papers and answers are provided.

Professor Miller's *Engineering Mathematics*, written with the first year graduate engineering student in mind and in order to strengthen his mathematical background, could profitably form a sequel to such a course as that of Dr. Starr. A brief introductory account of determinants and matrices is followed by a chapter on integrals, introducing the gamma error and sine-integral functions, elliptic integrals and Stirling's formula. The general theory of linear differential equations and the Frobenuis method of solution in series is continued in chapters on Fourier series and integrals and the Laplace transform. Illustrative examples are mainly drawn from electrical engineering. One chapter is devoted to network theory and another to random functions, stressing their relevance in communication engineering. Selected references for further reading are given at the ends of the chapters.

Many problems arise in engineering practice which, when translated into mathematical terms, defy analytical solution, so that recourse must be made to approximate methods of solution. Even by pure mathematicians these are no longer dismissed as mere matters of sordid routine beyond the pale of proper mathematics. The advent of high-speed electronic calculators has been largely responsible for a revival of interest in computational techniques which has led to improvements in the efficacy and accuracy of older procedures and to the emergence of new ones. *Numerical Methods in Engineering*, by Salvadori and Baron, is based upon a course offered in the School of Engineering at Columbia University. It starts with methods for evaluating the real and complex roots of algebraic and transcendental equations and the solution of systems of simultaneous linear equations, pointing out the merits of the Cholensky scheme. The remainder of the work, based on finite difference theory outlined in chapter two is devoted to the numerical integration of initial, and of ordinary boundary, value problems and to the numerical solution of partial differential equations. This approach makes for concise presentation and permits a simple estimation of errors. Illustrative examples relate to strength of materials, elastic stability, vibrations, heat flow and electrical circuits, while a representative selection of problems is included.

Dr. Fox's book, which is one of the Oxford Monographs on Numerical Analysis, concentrates on an important class of boundary value problems but treats it in considerably greater detail. Most of the methods suitable for pencil and paper and desk machine computation are critically examined, but methods of the Monte Carlo type which can only be handled by automatic computors are excluded. The first part deals with finite differences and the solution of algebraic equations, in particular with those arising from the replacement of derivatives by finite difference expressions, while the main portion of the book describes boundary value methods for differential systems of orders one to four including problems of eigen value type. Both linear and non-linear cases are considered. A chapter is devoted to a thorough investigation of accuracy and precision while careful consideration is given to procedures for saving labour without sacrificing accuracy. Each fresh point is illustrated by a worked example but the reader is left to devise his own problems for further practice. Practical hints, based upon a lengthy experience, abound and will prove invaluable to those embarking upon a career in computing.

How rewarding can be the outcome of studies in the domain of "workable" mathematics when carried out by so eminent a mathematician as Professor Lanczos is revealed in his *Applied Analysis*. His objective, brilliantly realised, is the analysis and design of finite processes which approximate the solution of an analytical problem and, as he points out in his preface, "to design procedures which will effectively minimise the error in a small number of steps and which will estimate the error with sufficient accuracy is not a matter of practical interest only but a matter of scientific interest as well." Moreover, as he shows, the requisite rigour can be secured without parading all the formal apparatus of pure mathematical deduction. The seven long chapters are devoted, respectively, to algebraic equations, matrices and eigen value problems, large scale linear systems, harmonic analysis, data analysis, quadrature methods, and power expansions. An appendix contains 15 numerical tables, most of them specially computed under the auspices of the National Bureau of Standards.

Of more theoretical interest are the use of geometrical interpretations to bring out the deeper implications of the nature of eigen value and interpolation problems, the numerical scheme evolved to facilitate the search for hidden periodicities, the illuminating discussions on orthogonality, perturbation methods, the application of the principle of least squares and the telescoping of power series by successive reductions. Of more immediate practical usefulness are the carefully selected examples illustrating procedures (rescaling, normalisation, etc.) for the preliminary processing of the data to lighten the subsequent labour of computation, the adoption of the movable strip technique, the handling of rounding errors and an occasional aside such as the quick method for obtaining the square root of a complex number. But no cursory sampling can convey any adequate impression of the wealth of material surveyed, the profoundly philosophical approach, bringing out the inter-relationship of its component parts, or the penetrating insight and originality of treatment to be found in this outstanding contribution to what Professor Lanczos has elected to call "parexic analysis." Though the results obtained by vector analysis can be, and in many textbooks still are, derived without its aid, the systematic use of vectors has decided advantages enabling formulae to be deduced more simply and directly and to be stated more compactly in a form independent of any particular co-ordinate frame of reference. Professor Brand's introductory course in vector analysis is well adapted to the needs of engineers. A clear exposition of the basic theory is provided in the first five chapters on vector algebra, line vectors, vector fields of one variable, differential invariants and integral theorems. Though dyadics and tensors are mentioned reference is made to the author's more advanced text *Vector and Tensor Analysis* for a fuller treatment of them. The remainder of the book deals with the application of vector analysis to selected problems in dynamics, fluid mechanics and electrodynamics and concludes with a chapter on abstract vector spaces (including the Hilbert space). Numerous examples are worked out and others are proposed as exercises.

Professor Thomson's little book covers the theory of the Laplace transformation and illustrates its application to a wide variety of problems in engineering and physics. After defining and developing the properties of the Laplace transform, typical dynamical problems leading to ordinary differential equations with constant coefficients are solved with its aid, including automatic control mechanisms, impact testing and the statical deflection of beams. Such parts of complex variable theory as are essential to a thorough understanding of the Laplace transform are then outlined and are followed by chapters on partial differential and difference equations with illustrations relating to water hammer, heat conduction, transmission lines, beam vibrations and multicylinder engines. The last two chapters are devoted to closed-loop systems and the important question of their stability, and to a brief account of electrical-mechanical analogies. Not only is this a text that demonstrates convincingly the scope and power of Laplace transform methods but it also provides, in over 200 problems, ample material for acquiring confidence in their use.

CLYDE COLLECTION

Descriptive Catalogue of Ship Models in the Glasgow Art Gallery and Museum, *Kelvingrove, Glasgow, C.*3. (4*s.*)

A museum without a catalogue is like a text-book without an index; the value of the contents is not affected, but its utility is diminished in proportion to the extra time that the visitor must spend in seeking by inquiry among the staff and elsewhere for the information that a catalogue should contain. The collection of ship models in the Kelvingrove Museum has suffered from this handicap for many years, but it has now been removed by the painstaking labours of Mr. Anthony S. E. Browning, the Curator of Shipping and Engineering, who is stated to have produced the first comprehensive catalogue of the collection of ship models.

Its value is the greater as only a portion of the collection can be exhibited at one time, pending the realisation of the ambition that Glasgow

should have eventually a separate museum for the marine collections. In point of date, the sailing ship models start with a scale model of the viking ship found at Gokstad, in Norway, made under the supervision of the Antiquarian Society of Christiania (according to the catalogue—now presumably " of Oslo ") and range to the close of the Nineteenth Century. Bone " prisoner of war " models are well represented; Scottish fishing craft not, perhaps, so well as they should be. One of the most interesting of the steamship models is undoubtedly that of Henry Bell's Comet (1812): a contemporary model, unrigged, but showing the twin paddles with which she was originally fitted. The subsequent development of the Clyde steamer is well illustrated and includes the King Edward (1901), the first turbine vessl in the world to go into commercial service. The Clyde enjoys such fame for the building of the larger passenger liners and warships that these classes are particularly fully represented; the Queen Mary is there, of course, and also H.M.S. Hood. Most of the models are of Clyde-built ships, but there are some notable exhibits from elsewhere, among which may be mentioned one of the handsomely proportioned (but not very efficient) City of Rome, built at Barrow for the Inman Line in 1881. It is a little strange, however, that the catalogue says nothing about the renowned sisters, City of Paris and City of New York, built at Clydebank in 1888-89 and the first express Atlantic liners to have twin screws; or of the still more widely known Cunarders, Campania and Lucania, built at Govan by the Fairfield Company in 1892-93. The museum does contain, however, a model of particular scientific interest, the Lucy Ashton, with which, for the first time, the British Shipbuilding Research Association were able to carry out a direct check on the resistance experiments of William Froude.

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NEW BOOKS

The Solidification of Castings. By R. W. RUDDLE. Institute of Metals Monograph and Report Series No. 7. Second edition. *The Institute of Metals, 17 Belgrave-square, London, S.W.*1. (42*s.*)

The main purpose of the author is to present to the reader, in readily assimilable form, the results of a critical survey of researches carried out in this and other countries, on the solidification of metals. Since the publication of the first edition of this monograph, in 1950, much has been published on the solidification of castings, and this has necessitated the entire revision of the text of the original edition and the inclusion of much new matter. As a result the present volume is nearly four times as long as its predecessor. Like the first edition, the work is addressed mainly to the research worker and foundry technologist, but it is felt that much of it should also interest the practical foundryman.

Set-ups on Automatics. Machinery's Yellow Back Series No. 41. *The Machinery Publishing Company, Limited, National House, 21 West-street, Brighton*, 1. (4*s.* 6*d.*)

Much development work has been done by manufacturers of automatics, to further the versatility of these machines, and the present work is intended to accent this aspect of the machine type, rather than to be representative of usual practice. It is divided into three chapters, which deal with single-spindle, multi-spindle and chucking machines respectively, and examples of components have been chosen to draw attention to special features of some of the machines and their attachments. Other components produced by the tooling arrangements described are representative of standard types used in the aircraft and automobile industries. The machines mentioned include British, American, German and Swiss.

British Diesel Engine Catalogue. Edited by D. S. D. WILLIAMS. Fourth edition. Published for the *British Internal Combustion Engine Manufacturers' Association, 6 Grafton-street, London, W.*1, by *Temple Press, Limited, Bowling Green-lane, London, E.C.*1. (52*s.* 6*d.*)

In style the volume follows the general lines adopted by the preceding issues, but there have been improvements and additional information has been included. Sections of the catalogue are printed in French, Spanish, Portuguese and German, as well as English, and there is a complete glossary in these languages of the technical terms and abbreviations used. 2,893 engines of 43 makes are described and tabulated, which is some 20 per cent. greater than in the third edition of this work.

Satellites and Spaceflight. By ERIC BURGESS. *Chapman and Hall, Limited, 37 Essex-street, London, W.C.*2. (21*s.*)

The author, a past chairman of the British Interplanetary Society, provides in this book a general guide to the problems and possibilities of space exploration " in the light of to-day's scientific and technical knowledge." In the chapter on instrumented satellites are discussed the technical problems of placing them in orbit, and the scientific work for which they are to be used. This chapter is dated only in so far as there is no reference to the Sputniks, since the book went to press some months before they were launched; the general picture of the scale and purpose of the operation has, so far, not been modified by the Sputniks' career. Subsequently, the author deals with the physical and physiological problems of setting up a manned station in space, telemetering " probe " missiles designed to orbit the moon and planets and transmit scientific data, manned expeditions to the moon (unlikely in less than 25 years time) and setting up a fuelling and laboratory base there, and finally interplanetary travel.

Chemical Engineering in the Coal Industry. Edited by FORBES W. SHARPLEY. *Pergamon Press, Limited, 122 East 55th-street, New York* 22, *N.Y., U.S.A.* (8.50 dols.); and *Pergamon Press, Limited, 4 and 5 Fitzroy-square, London, W.*1. (50*s.*)

The papers presented at an international conference organised by the National Coal Board of Great Britain and held at its Coal Research Establishment at Stoke Orchard, Cheltenham, in June, 1956, have now been collected and issued in book form, together with the discussions which took place at the four technical sessions. The opening address by Mr. A. H. A. Wynn and the closing address by Dr. J. Bronowski are also included. The authors of the papers came from France, the Netherlands and Germany, as well as from this country.

On the Shelf

By Frank H. Smith

The Pergamon Press would appear to be quite insatiable. They have now announced an " International Series of Monographs on Aeronautical Sciences and Controlled Flight," with close on fifty authorities on its honorary advisory board. The list of the board members looks more like the author-index of an aeronautical library. Aeronautics is fortunate in benefiting from so much altruism.

The Bureau of Technical Information, which is run in connection with I.O.T.A. Services Limited (short for Index of Technical Articles), of 38 Farringdon-street, London, E.C.4, has issued its first bibliography on computers. This represents a month's output of references on this particular subject and the implications of its 27 foolscap pages are quite frightening. Where *does* all this literature come from? Who reads it? How long will paper last at this rate?

Mrs. K. Bourton, whose compilation this is, has had previous experience of bibliography preparation and the hand of experience is manifest. It is, perhaps, unfortunate that the one item in which I have a personal interest appears in the body of the bibliography but is not indexed under either of the two authors. This is, however, a quibble and I would commend this service particularly to hard-pressed librarians and, providing they do not require a bibliography service on too many subjects, the fee should not be too exorbitant for the approval of the firm's accountant.

The U.S. Department of Commerce, Washington, 25, District of Columbia, announces a new publication *Screw-Thread Standards for Federal Services*, 1957, which may be obtained from the U.S. Government Printing Office, at the same address, or through H.M. Stationery Office. This publication represents an attempt to promote uniformity in screw-thread standards between the Departments of the Army, Navy, Air Force, Commerce and Defense (sic). No mention is made of the attempts which have been made to make these standards international. It would seem that the whole work will constitute three volumes and the one under reference is Part I, H.28 (1957). It supersedes Sections I to V, XV and XVI and Appendixes 1, 2, 6 and 8 of Handbook H.28 of 1944. I tell you all this in case you have it. If you want the new one, the cost of this part is 1.25 dols.

B.S.I. News for October carries the announcement of B.S. 2911, covering letter plates. This is what is popularly known as a letter box and the standard aperture will measure 8 in. by 1¼ in. When I read this I looked at a ruler to get an idea of the size and I think it a great pity that none of those responsible had ever done a newspaper " round." I have, and I know that the average newspaper, plus a woman's weekly, plus a *Radio Times* will go through such an aperture only with the aid of a pot of Vaseline and a shoe-horn. A recommended height of from 2 ft. 6 in. to 4 ft. 9 in. is good, but the higher position is definitely to be preferred.

Mr. Bernard L. Foy, Technical Librarian of the Tennessee Valley Authority, Knoxville, Tennessee, U.S.A., has " noted our interest in this subject and thought we would be interested in having a copy of this recent bibliography." Mr. Foy is quite right and I accordingly hand on the information that additional copies of *Pumped Storage for Hydroelectric Power*—a selected list of references in English—are free on request. Prepared in September, this eight-page bibliography ranges from May, 1935, to August, 1957. How fortunate Mr. Foy is in being librarian of a body the mere initials of which—T.V.A.—have an international fame. To me they are associated with interesting documentary cinema films.

The North-Holland Publishing Company, P.O. Box 103, Amsterdam, issues some good material in a quiet way—particularly on nuclear physics. One of their new titles, however, intrigues me; it is *White Dwarfs* by E. Schatzman. It seems that only about 200 of these things have been identified and only a dozen studied. Their faintness precludes close study. What are they? I simply don't know and the matter doesn't help much, except to state that the " theory of White Dwarfs is vital to astronomy."

On November 6, the Aslib Aeronautical Group held a small meeting at the Royal Aircraft Establishment, Farnborough, at which two papers on classification schemes (yes—*another* two) were read. Mr. J. Rosser, of the Aircraft Research Association, produced one on " A method of co-ordinate indexing based on the N.A.C.A. subject classification," and Mr. C. Wilson, Aerodynamic Librarian of the Royal Aircraft Establishment, read " A new classification for aeronautics." In accordance with contemporary styling, both had a numerical foundation and both dealt mainly with aerodynamics. One feels rather sorry for the aerodynamicists of this world. Not only have they their own problems to solve but they also have to share the difficulty of the librarian in pinpointing a particular piece of information. They spend hours trying to evolve a fool-proof system of indexing that will save them hours searching for the solution to a problem that might take them hours to work out themselves. It is just a question of which hours are the shortest.

Jonathan Cape (the publishers) have, since 1921, issued a rather delightful journal called *Now and Then*. As its title implies, this comes out at no set dates but it has just celebrated its 100th number with a magnificent gold cover chastely titled. Extracts are made from previous numbers, down the years, and I would like to quote many of them but space forbids.

Design

PHYSICS IN REACTOR DESIGN

A Pictorial Summary of Elementary Nuclear Concepts

Continued from page 726

Reactor physics has assumed importance for many engineers already engaged in their profession but whose training has included no foundation in nuclear science. For these and others requiring a quick introduction to the subject, Mr. G. W. K. Ford has prepared the present article. The first part was concerned mainly with basic nuclear physics; the present section deals more specifically with reactor physics. Later sections will treat such problems as critical size, slowing-down of neutrons, reflected reactors, group theories and breeding. Mr. Ford is Research Manager of the experimental criticality group in the United Kingdom Atomic Energy Authority's establishment at Dounreay.

By G. W. K. Ford, M.B.E., M.A., A.M.I.MECH.E., A.M.I.E.E.

(B) BASIC REACTOR PHYSICS: MONOKINETIC REACTOR

(1) Neutron Multiplication

Multiplication of Neutrons in Infinite System (*Fig.* 13).—The diagram in Fig. 13, represents a portion of an "infinitely" large volume of a mixture of a fissile and a non-fissile material. The latter is assumed either to scatter or to absorb neutrons which interact with its nuclei. For the theory developed in this section it will be assumed that the neutrons retain the energy with which they were born throughout the scattering processes, that is slowing-down is negligible, and all the neutrons have only one energy. Since the neutrons are assumed monokinetic, all the cross-sections for the various processes will be constant. Imagine one neutron to enter the volume being considered. Providing there are not too many absorbing nuclei present it is evident that, because U235 (say) produces about 2·5 neutrons per fission it will, on the average, be possible to get more than one neutron produced for each one absorbed in the postulated mixture. In the diagram, seven neutrons have been absorbed by the various competing processes and ten neutrons have been produced so that there has been a net gain of three neutrons. The important quantity k_∞ is defined as the number of neutrons born per neutron absorbed within an infinite volume of given mixture, averaged over a very large number of neutron interactions. (For the trivial number of processes in the diagram, "k_∞" is $\frac{10}{7}$). If k_∞ is larger than unity it is possible, given enough material, to initiate a self-sustaining or a diverging chain reaction. If k_∞ is less than unity a self-sustaining chain reaction is not possible, and any chain of fission processes started will die out due to excessive neutron absorption.

Neutron Cycle in Infinite System (*Fig.* 14).—The diagram is a useful way of representing an average cycle of neutron generation, and may be taken to represent either the history of a neutron population of n neutrons within a given unit volume (see lower part of Fig. 16), or to account for the fortunes of a particular n neutrons individually followed. Considering the latter concept for the present paragraph, suppose n neutrons are released in the infinite system. First, a fraction $(1 - f)$ will be absorbed in parasitic absorbers such as items of the reactor's structure or coolant. The fractional quantity f is called the fuel utilisation factor, and is obtained directly for a simple homogeneous mixture of two materials, the one fissile (say, uranium) and the other non-fissile (say, a moderator) from the ratio of the cross-sections (σ) and number of atoms (N) of each type of material per cub. cm. of mixture:

$$f = \frac{N_u \sigma_{cu}}{N_u \sigma_{cu} + N_{nf} \sigma_{nfa}} = \frac{\Sigma_{cu}}{\Sigma_{cu} + \Sigma_{nfa}}$$

where the suffixes mean:

- u = uranium (or other fissile material).
- cu = capture in uranium (fission + non-fission capture).
- nf = non-fissile (refers to moderator, structure materials, etc.)
- nfa = non-fissile absorption.
- Σ = $N\sigma$ (see (2) below, under Fig. 16).

The remaining fn neutrons are available to be absorbed in fissile material (fuel). But of these a fraction $\left(\frac{\alpha}{\alpha+1}\right)$ are wasted in non-fission capture in the fuel. The remainder, $\left(\frac{1}{\alpha+1}\right) fn$, cause fissions, producing $\left(\frac{\nu}{\alpha+1}\right) fn = \eta\, fn = k_\infty\, n$ new neutrons. If $k_\infty\, n$ is equal to or larger than n, that is if $k_\infty \geqslant 1$, the chain reaction will be self-sustaining and at least n neutrons will be available to be fed back into the system to produce another generation of neutrons, leaving $(k_\infty - 1)\, n$ surplus neutrons. The whole of this surplus must either be absorbed or allowed to leak out of the system (by making it of finite size) if a steady-state chain reaction is required.

Reactor Period (*Fig.* 15).—In a finite system the number of neutrons available to commence the next cycle could not possibly be as large as $k_\infty\, n$ because of leakage of neutrons from the surface of the system. The leakage reduces it to a smaller value, $k\, n$, where $k = 1$ for a steady-state system, or if $k > 1$ the chain reaction will diverge. The average time elapsing between the birth and death of a neutron (Λ in Fig. 15) depends upon the type of fissile mixture being considered and upon the average velocity of the neutrons between birth and death. In thermal reactors much of the neutron lifetime (of order 10^{-3} sec.) is spent diffusing at the relatively slow thermal equilibrium velocities, but in a fast reactor the diffusing neutrons travel at about 10,000 times the speed of the thermal neutrons and so meet their fate much sooner: only about 10^{-7} sec. elapses between birth and death. Substitution in the formula given shows that with such short lifetimes very rapid neutron multiplication results even for small values of $(k - 1)$, which would make mechanical control impracticable. Fortunately, if the excess of k above unity depends upon the 0·4 per cent. to 0·7 per cent. of the total neutrons generated per cycle which are not born promptly at the moment of fission but which are delayed and emitted later by certain of the fission fragments, then the average or effective neutron lifetime is as long as one-tenth of a second, because, even though the fraction of delayed neutrons is only small (0·73 per cent. for U235), their mean lifetimes are long, their effective average lifetime being greater than 10 seconds. The yield of delayed neutrons and average lifetimes differs between fissile isotopes so that the effect must be considered separately for each type of nuclear fuel.

(2) Neutron Interactions: Mean Free Path

Interactions of Neutrons with Nuclei (*Fig.* 16).—To carry out calculations upon reactor systems it is necessary to be able to calculate the effects of neutron interactions in macroscopic volumes of material. Consider first a collimated beam of neutrons of 1 sq. cm. cross-sectional area moving at a constant velocity v and passing through a sheet or slab of material 1 cm. thick. Notice that in general $v > 1$ cm. per sec. (between 10^5 and 10^9 cm. per sec. in reactors). Assume for this purpose that the nuclei are so small that their projected disc-areas do not overlap, and, if a scattering process is being considered, that after one collision the neutron concerned disappears from the system; that is there is no multiple scattering. If there are N nuclei per cub. cm. each of area σ sq. cm. then the total disc area presented to the beam is $N\sigma$ sq. cm. per cub. cm. (It is assumed that $N\sigma < 1$ for the present discussion; for large cross-sections the reasoning still applies to thin foils of material.) $N\sigma = \Sigma$ is termed the macroscopic cross-section for the material. If the neutron beam contains n neutrons per cub. cm. (that is n neutrons per cm. of its length) the number contained in the length (> 1 cm.) of the beam which will pass through the slab in 1 sec. is nv, spread uniformly over the cross-section of the beam. But an area $N\sigma$ is blocked by target nuclei, so the fraction $\frac{N\sigma\,(\text{sq. cm.})}{1\,(\text{sq. cm.})}$ of nv will be "filtered" out of the beam. Notice that since all of the nv neutrons each pass through 1 cm. of material, the total track length they trace out in 1 sec. within the material is also nv. In a multiplying mixture (or in any diffusion process) the neutrons travel in random directions and the neutron flux ϕ is defined as the total track length travelled by neutrons within 1 cub. cm. in 1 sec. and is also equal to nv where n is the average neutron population per cub. cm. and v is the average neutron velocity. The number of interactions per second is, as before, $N\sigma \times nv = \Sigma\phi$.

Finally, referring back to Figs. 9 and 12, notice that if, say, fission of U235 is being caused by neutrons having energies distributed over, say, the Maxwellian thermal spectrum range, then the number of interactions per cub. cm. per sec. is obtained by integrating the expression $n\,(E)\, v\,(E) \times N\sigma\,(E)\, dE$ over the given energy range, where $n\,(E)$ is the number of neutrons per unit energy interval (1 eV), v is the velocity corresponding to the mean of the energy interval, N is the number of target nuclei per cub. cm. of the substance in which the reaction is taking place, and $\sigma\,(E)$ is the cross-section for the process (fission in this case) at the energy being considered. For a much used spectrum such as the thermal Maxwellian, experimentally measured mean values of σ are available which, when multiplied by the integrated thermal neutron flux $\left(\int n\,(E)\, v\, dE\right)$ give directly the number of interactions per cub. cm. per sec. Such values can be used for calculations using a monokinetic model of the diffusing system in which the neutron velocity and the cross-sections are assumed constant. In other cases special methods of averaging must be used to enable practical calculation work to be done, the method depending upon the state of the available data.

Meaning of the Neutron Flux (*Fig.* 17).—It is sometimes helpful to have an alternative physical concept of neutron flux to that of the total track length per cub. cm. per sec. referred to above; for example in considering the radioactivation of a metal foil placed inside a nuclear reactor to measure the neutron-flux intensity. Consider for the present discussion a non-absorbing, non-scattering thin plane foil of one centimetre square placed in the flux. If this flux is a collimated beam containing n neutrons per cm. cube,

(5) Neutron multiplication

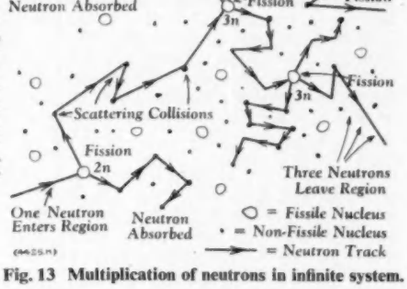


Fig. 13 Multiplication of neutrons in infinite system.

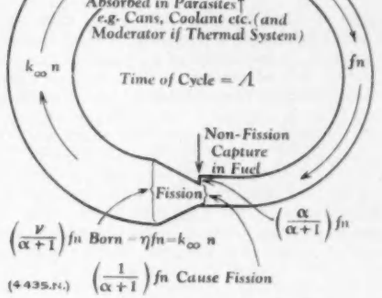

$(k_\infty - 1)n$ Surplus Neutrons
n Enter Cycle
fn Enter Fuel
$k_\infty n$
$(1-f)n$
Absorbed in Parasites e.g. Cans, Coolant etc. (and Moderator if Thermal System)
Time of Cycle = Λ
Non-Fission Capture in Fuel
Fission
$\left(\frac{\nu}{\alpha+1}\right) fn$ Born $= \eta fn = k_\infty n$
$\left(\frac{1}{\alpha+1}\right) fn$ Cause Fission
(4435.N.)

Fig. 14 Neutron cycle in infinite system.

n_0 neutrons per cm.³ of reactor at time $t = 0$.
$k\,n_0$ after one generation of neutrons.
$k\,(k\,n_0) = k^2\,n_0$ after two generations.
$k^m\,n_0$ after m cycles $= n = (1 + \Delta k)^m\,n_0$

$$m = \frac{\text{Time for } m \text{ cycles}}{\text{Neutron generation time}} = \frac{t}{\Lambda}$$

$$\text{Log}_e \frac{n}{n_0} = m \log_e (1 + \Delta k)$$

$$= m\left[\Delta k - \frac{(\Delta k)^2}{2} + \frac{(\Delta k)^3}{3} - \ldots\right]$$

$$\simeq m\,\Delta k \text{ for small } \Delta k\ (\simeq 0{\cdot}005)$$

$$\therefore \quad n = n_0 e^{m\Delta k} = n_0 e^{\frac{\Delta k}{\Lambda} t} = n_0 e^{\frac{t}{T}}$$

T = Reactor period = "e-folding time" $= \dfrac{\Lambda}{\Delta k}$

$\Lambda \simeq 10^{-7}$ sec. for fast reactor ($\Delta k > 0{\cdot}007$).
$\simeq 10^{-3}$ sec. for thermal reactor ($\Delta k > 0{\cdot}007$).
$\simeq \frac{1}{10}$ sec. if Δk due to delayed neutrons ($\Delta k < 0{\cdot}007$)
(Delayed neutrons born up to minutes after fission.)

Fig. 15 Reactor period.

(6) Neutron interactions: mean free path

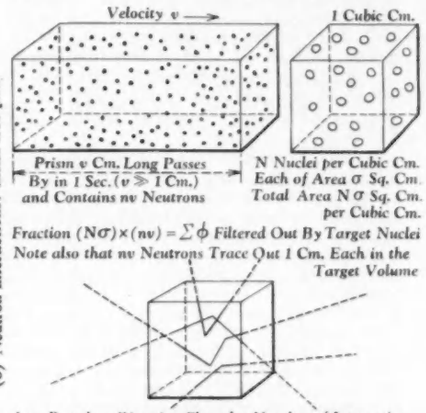

Velocity v
1 Cubic Cm.
Prism v Cm. Long Passes By in 1 Sec. ($v \gg 1$ Cm.) and Contains nv Neutrons
N Nuclei per Cubic Cm. Each of Area σ Sq. Cm. Total Area $N\sigma$ Sq. Cm. per Cubic Cm.
Fraction $(N\sigma) \times (nv) = \Sigma\phi$ Filtered Out By Target Nuclei
Note also that nv Neutrons Trace Out 1 Cm. Each in the Target Volume
In a Ramdom Direction Flux also Number of Interactions per Sec. = (Total Track Length per Cubic Cm. Sec.) × ($N\sigma$)
(4435.O)

Fig. 16 Interaction of neutrons with nuclei.

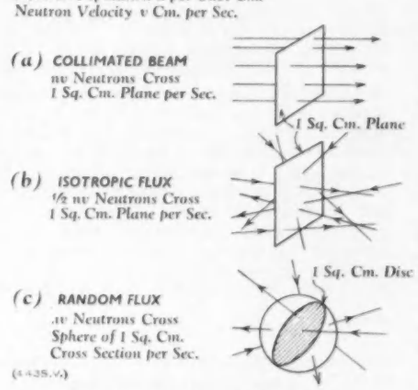

Neutron Population n per Cub. Cm.
Neutron Velocity v Cm. per Sec.
(a) COLLIMATED BEAM
nv Neutrons Cross 1 Sq. Cm. Plane per Sec.
1 Sq. Cm. Plane
(b) ISOTROPIC FLUX
½ nv Neutrons Cross 1 Sq. Cm. Plane per Sec.
(c) RANDOM FLUX
nv Neutrons Cross Sphere of 1 Sq. Cm. Cross Section per Sec.
1 Sq. Cm. Disc
(4435.V.)

Fig. 17 Meaning of neutron flux.

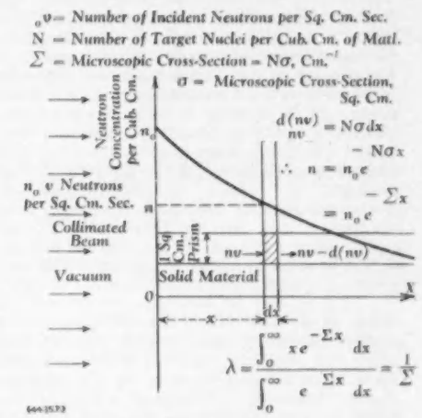

$_0v$ = Number of Incident Neutrons per Sq. Cm. Sec.
N = Number of Target Nuclei per Cub. Cm. of Matl.
Σ = Microscopic Cross-Section = $N\sigma$, Cm.$^{-1}$
σ = Microscopic Cross-Section, Sq. Cm.
Neutron Concentration per Cub. Cm.
n_0 v Neutrons per Sq. Cm. Sec.
Collimated Beam
1 Sq. Cm. Prism
nv
$nv - d(nv)$
Vacuum
Solid Material
$d(nv) = N\sigma\,dx\,nv$
$= -\Sigma x$
$\therefore n = n_0 e^{-\Sigma x}$
$\lambda = \frac{\int_0^\infty x e^{-\Sigma x}\,dx}{\int_0^\infty e^{-\Sigma x}\,dx} = \frac{1}{\Sigma}$
(4435.T.)

Fig. 18 Mean free path.

(7) Neutron diffusion

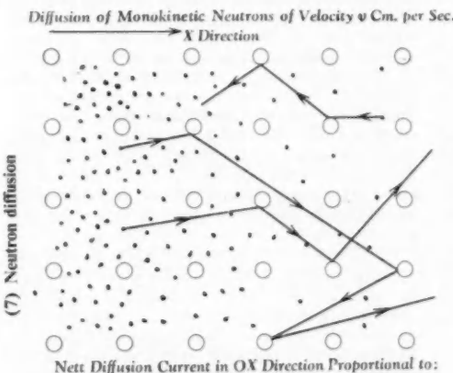

Diffusion of Monokinetic Neutrons of Velocity v Cm. per Sec.
X Direction
Nett Diffusion Current in OX Direction Proportional to:
(Spacing Between Nuclei) × (Smallness of Nuclei)
× (Velocity of Neutron) × (Concentration Gradient) or:
$J_x = \frac{1}{3} \times \frac{1}{N} \times \frac{1}{\sigma_s} \times v \times \left(-\frac{dn}{dx}\right) = -\frac{\lambda_s}{3} v \frac{dn}{dx} = -D_o \frac{dn}{dx} = -D \frac{d\phi}{dx}$
(4435.Q.)

Fig. 19 Neutron current.

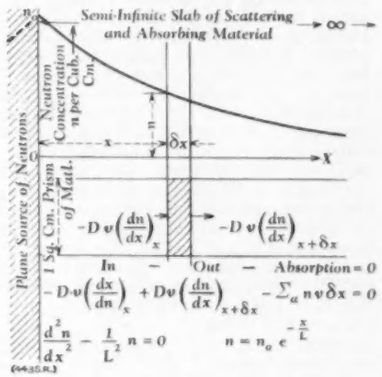

Semi-Infinite Slab of Scattering and Absorbing Material
∞
Neutron Concentration n per Cub. Cm.
Plane Source of Neutrons
1 Sq. Cm. Prism of Matl.
$-D\,v\left(\frac{dn}{dx}\right)_x$
$-D\,v\left(\frac{dn}{dx}\right)_{x+\delta x}$
In − Out − Absorption = 0
$-D\,v\left(\frac{dn}{dx}\right)_x + D\,v\left(\frac{dn}{dx}\right)_{x+\delta x} - \Sigma_a\,n\,v\,\delta x = 0$
$\frac{d^2n}{dx^2} - \frac{1}{L^2} n = 0$
$n = n_0 e^{-\frac{x}{L}}$
(4435.R.)

Fig. 20 Neutron diffusion length.

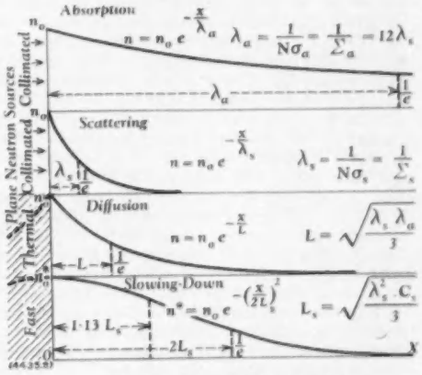


Fig. 21 Characteristic lengths.

(8) Critical reactor

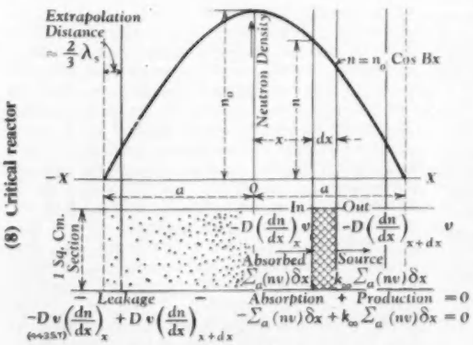


Fig. 22 Infinite slab monckinetic critical reactor.

$$D v \left(\frac{d^2n}{dx^2}\right) + (k_\infty - 1)\,\Sigma_a\,(n v) = 0$$

or: $$\frac{d^2n}{dx^2} + \frac{(k_\infty - 1)\,\Sigma_a}{D} n = 0$$

$$D = \frac{\lambda_s}{3}; \quad \Sigma_a = N\sigma_a = \frac{1}{\lambda_a}; \quad \frac{D}{\Sigma_a} = \frac{\lambda_s \lambda_a}{3} = L^2;$$

$$B^2_m = \frac{(k_\infty - 1)}{L^2}$$

so: $$\frac{d^2n}{dx^2} + B^2 n = 0 \quad \text{or:} \quad \frac{d^2n}{n} = -B^2$$

At $x = 0$, $n = n_0$; at $x = a$, $n = 0$

$n = n_0 \cos B_g x$ where $B_g = \frac{\pi}{2a}$

Critical if $B_m = B_g$;

then $$k_{eff} = 1 = k_\infty \left(\frac{1}{1 + L^2 B^2}\right)$$

Fig. 23 Critical equation.

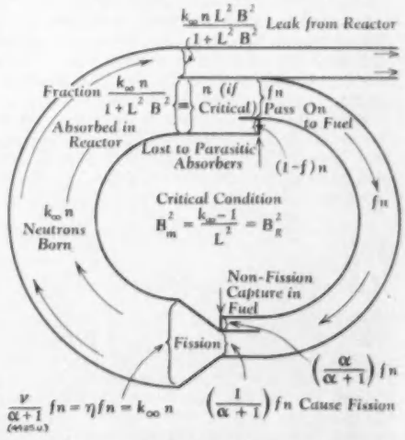


Fig. 24 Neutron cycle in finite-sized one-group reactor.

Continuing Design

as in Fig. 16, then each second a total of $n\,v$ neutrons will pass through the foil. But if the foil is placed in an *isotropic* flux, analysis shows that a total of only $\frac{1}{4}\,n\,v$ neutrons cross the foil each second; in this second case the neutrons enter the foil from all directions with equal probability. The association of the flux $n\,v$ with an area can be retained, however, if the following mental artifice is employed. Imagine a 1 sq. cm. circular disc-foil which can be magically twisted about its centre so that each approaching neutron enters it, from the same side, in turn, and such that its track is perpendicular to the disc. In a neutron population of n neutrons per cm. cube, each neutron having velocity v cm. per sec., it is clear that a total number $n\,v$ neutrons must cross the disc in each second by analogy with the top of Fig. 16: for so far as the disc is concerned each neutron entering its surface might just as well have travelled from infinity in a straight track (instead of as it actually has arrived, directly from a fission or from a scattering collision), and therefore, so far as the disc is concerned, the effect is the same as if it were stationary in a collimated beam. In its twisting the disc has intercepted all neutrons passing through the sphere enclosing it, and it is therefore apparent that in a randomly directed neutron flux (that is whether collimated, isotropic or mixed) of mean population n neutrons per cm. cube each of velocity v cm. per sec. a total number of $n\,v$ neutrons will *cross* (that is enter and leave) a sphere of cross-sectional area equal to 1 sq. cm. This is a sphere of 1·113 cm. diameter.

Mean Free Path (*Fig.* 18).—The mean free path λ can be defined in two different ways which are, of course, identical in value: (*a*) it is the average distance travelled by the projectile (neutron) between collisions in scattering processes, or between entering a system (or birth within it) and death (capture) in absorption processes; or (*b*) it is the distance of penetration of a collimated beam of neutrons into a material at which the beam intensity falls to $1/e$ of its initial value (that is the relaxation length). The diagram in Fig. 18 represents a collimated beam of monokinetic neutrons entering the face of a semi-infinite slab of scattering or absorbing material. We consider a 1 sq. cm. prism of the material extending from $x = 0$ to infinity, and consider the nuclear interactions taking place in the shaded element situated between x and $x + \delta x$. In this element of material $d(n\,v)$ neutrons are absorbed (or scattered out of the beam.) But this must be equal to the number of interactions per second within the elemental volume as obtained in the section referred to in Fig. 16, namely $(N\,\delta x)\,\sigma \times n\,v$; hence the differential equation shown and its solution, also represented by the exponential curve sketched which shows the falling-off of n, the neutron population per cub. cm., with increasing values of x. The *mean* distance of penetration of the neutrons into the block is clearly obtained by adding up (over a period of one second, say) the distances which each neutron penetrates into the block and dividing by the total number of neutrons which entered the block (in one second). The number of neutrons travelling a distance between x and $(x + \delta x)$ in one second is $n_0 v \exp.(-\Sigma x)\,d\,x$, and their track length in the material is therefore $x\,n_0\,v \exp.(-\Sigma x)\,d\,x$. Thus the total track length in one second is $\int_0^\infty x\,n_0\,v \exp.(-\Sigma x)\,d\,x$ The total number of neutrons is simply $\int_0^\infty n_0\,v \exp.(-\Sigma x)\,d\,x$ [Exp.$(-\Sigma x) \equiv e^{-\Sigma x}$]. Since n_0 and v are constants, the expression for the mean penetration is seen to be as given for λ in Fig. 18. Each time x increases by an amount λ the beam intensity is reduced by a factor e. Qualitatively the mean free path depends directly upon: (the spacing between target nuclei) times (the smallness of the target nuclei), quantitatively that is:

$$\lambda = \left(\frac{1}{N}\right) \times \left(\frac{1}{\sigma}\right) = \frac{1}{\Sigma}.$$

(3) Neutron Diffusion

Neutron Current (*Fig.* 19).—The diagram in Fig. 19 represents a few nuclei (white circles) in a portion of the lattice of a crystallite in a semi-infinite slab of material. The neutron concentration gradient is established in the OX-direction, and there is assumed to be no change of neutron concentration in the other two directions. The target nuclei scatter but do not absorb. The diffusing neutrons travel in random directions, but because there are more of them on the left than on the right there is a net drift to the right. On general physical grounds one would expect the net flow of neutrons to the right, that is the neutron current, to depend upon: $\left(\text{the spacing between the target nuclei, } \frac{1}{N}\right) \times \left(\text{the smallness of the nuclei, } \frac{1}{\sigma_s}\right) \times$ (the velocity of the neutron, v) $\times \left(\text{the concentration gradient, } -\frac{dn}{dx}\right)$. The derivation of this expression from first principles, together with the constant $\frac{1}{3}$, is simple and is given in the standard text-books, but will not be given here because the derivation is not essential to the main argument being presented. The two different neutron diffusion constants, D_0 and D, should be noted. D_0 contains v, the neutron velocity, and applies when writing equations in terms of neutron concentration gradient. D, the diffusion constant for flux, which refers to neutron flux ($\phi = n\,v$) gradient contains only $\frac{\lambda_s}{3}$.

Neutron Diffusion Length (*Fig.* 20).—Analogous to the mean free path is the diffusion length L, which is directly related to the crow-flight distance which a neutron will diffuse in a substance, or mixture of substances, in which both scattering *and* absorption may take place, between entering the system (or being born within it) and being absorbed. A semi-infinite slab of the scattering-absorbing mixture is considered in the diagram of Fig. 20; neutrons enter the slab in random directions from the plane source of neutrons on the face of the slab. Note that this differs from the collimated beam postulated in the section referred to Fig. 18, for in this case not only do the neutrons enter the slab from random directions, but there is also back-diffusion across the source plane. It is simplest, therefore, to consider the source plane to be backed by a second semi-infinite slab extending in the — OX-direction, thus providing an "infinite" reflector. There will therefore be a mirror image of the neutron distribution shown in the reflector. Again we consider a prism of 1 sq. cm. cross-section extending from $x = 0$ to infinity, and consider the competing nuclear processes within an element between x and $x + \delta x$. We assume no concentration gradient in the OY, OZ-directions (that is perpendicular to OX) and assume that a steady state exists. Therefore there is no change of the total neutron population within the element with time, and consequently the difference between the number diffusing into the element and the number diffusing out of it per second must be equal to the number absorbed within it. Hence the differential equation given, and its solution for the boundry conditions of the problem. Notice that the neutron population decreases by a factor e for each increment of L in the value of x, as in Fig. 18. L is called the diffusion length, and is the average distance of penetration of neutrons into an infinite diffusion-absorption medium from an infinite plane source. The result may be shown by averaging as in Fig. 18.

Characteristic Lengths (*Fig.* 21).—In the diagram of Fig. 21 the results of the sections referred to Figs. 18 and 19 are brought together for comparison. To illustrate the processes a substance which has an absorption mean free path of 12 times the scattering mean free path has been assumed. It is seen that the diffusion length is much shorter than the absorption mean free path (λ_a); this is because the scattering process is randomly directed and although the average neutron will in fact travel one absorption mean free path between entering the system and death by absorption, the neutron track is now a random zig-zag path (see Fig. 28, later), of totalled length λ_a, and the crow-flight distance is L. The diffusion length is proportional, then, to the geometric mean of the scattering and absorption mean free paths, and since each mean free path is proportional to 1/N, the diffusion length is also proportional to 1/N, that is inversely proportional to the density of the diffusing medium. In passing, it is worth noting that for accurate work it is necessary to take account of anisotropic scattering, particularly if the scattering nuclei have a low atomic weight, and in this case a modified value of λ_s called the transport mean free path (λ_{tr}) would be used which is slightly larger than λ_s. This detail will be neglected in the present treatment.

If fast (for example, fission) neutrons enter a diffusing medium they will not be in kinetic-energy equilibrium with the thermal vibrational energy of the nuclei of the medium, and therefore at each collision the neutrons will lose kinetic energy and hence be slowed down until ultimately they do come into thermal-energy equilibrium with the medium. The maximum average energy loss per collision occurs if the target nuclei have the same mass as the neutron and therefore, since the mass of the neutron is almost the same as that of the nucleus of the lightest atom, hydrogen, it is to be expected that the maximum energy loss per collision will occur with a hydrogen-containing moderator. To reduce the energy of neutrons from, say, fission energy to, say, thermal energy will require on the average a certain number of collisions, C_s, a number which becomes larger as the atomic weight of the moderator nucleus increases. Between each collision the neutron will travel, in a straight line, a distance governed by the scattering cross-section of the moderating nucleus, namely the mean free path, the total track between the two energies being a zig-zag track of total length $C_s\lambda_s$. The crow-flight distance between the ends of the total track traversed by the average neutron in undergoing C_s collisions and so, on the average, loosing a given amount of energy, will also be directly related to the number of collisions C_s and the scattering mean free path, λ_s. (It turns out to be $\sqrt{2C_s}\,\lambda_s$ as will be seen later in Fig. 28.) It is usually assumed that there is no absorption of neutrons by the moderating nuclei during the slowing-down process since the absorption cross-sections for fast neutrons are small compared with those for thermal neutrons and the scattering cross-section for a good moderator is large compared with its absorption cross-section.

The diffusion-slowing-down process therefore has a characteristic length which may be compared with that of the diffusion-absorption process. The fourth part of Fig. 21 shows the population distribution n^* of neutrons of a narrow energy range characterised by their having undergone an average number of collisions C_s after originally entering the slab as (monokinetic) fast neutrons at the source plane. Again, the source plane is backed by a semi-infinite reflector of the same moderating material, and again there is a mirror image of the slowed-down-neutron population distribution curve in the reflector because of two-way slowing-down-diffusion across the source plane. (Note that the number of neutrons produced per sec. per sq. cm. of the source plane is *not* the same as n_0^*, the concentration of neutrons of a particular energy range at $x = 0$.) Using the formula, derived from slowing-down theory, given in Fig. 21, for the distribution of the slowed-down

neutrons it can be readily calculated by an averaging process, as used for mean free paths in Fig. 18, that the *average* distance which neutrons of the particular energy being considered (that is the energy remaining after C_s collisions) penetrate into the semi-infinite slab from the source plane is $\sqrt{4/\pi}\ L_s = 1{\cdot}13\ L_s$ where L_s is directly related to the scattering mean free path λ_s and number of collisions C_s as shown in the right-hand side of the figure. The slowing-down length will be seen to have a simpler relationship to the diffusion length for the case of spherical geometry to be considered later, but the present comparison does give an initial physical picture of the significance of the characteristic lengths. If C_s is the number of collisions required to reduce the energy of the neutrons to just above thermal energy, then those neutrons lost to the energy range whose distribution is shown (this is analogous to the absorption in the diffusion-absorption process) become thermalised and then undergo the diffusion-absorption process. It will be seen later that in the case of a reactor in which the neutrons are born at fission energy and are absorbed at thermal energy the characteristic length for the crow-flight track of neutrons is the migration length M, which is a combination of the two diffusive processes discussed above; it will be shown that $M^2 = L_s^2 + L^2$. The concept of migration length is discussed in more detail in section D, to be published later, but is used before that in section C (2) and has therefore been mentioned at this point although it is not required for the completion of the monokinetic reactor theory as developed in Figs. 13 to 24.

(4) Critical Reactor

Infinite Slab Monokinetic Critical Reactor (*Fig.* 22).—Consider an infinite slab of a multiplying mixture of thickness just less than $2a$ cm. A self-propagating chain reaction is in progress and the neutron population density is constant, falling to zero at or near to the boundary. It is assumed that there is a vacuum on each side of the slab, so that neutrons leaking out of the system are not reflected back. Since there is a finite outward leakage the neutron density at the physical boundary cannot really be zero, and a convention is employed to account for this; the neutron density at the physical boundary is extrapolated linearly to the point where it cuts the OX-axis, that is, n is zero. This distance can be shown to be $\frac{2}{3}\lambda_s$ for a plane boundary. The real thickness of the slab reactor now to be studied will therefore be $2a - \frac{4}{3}\lambda_s$. Consider as before a 1 sq. cm. prism extending across the reactor in the OX-direction. Consider an element (shaded) between x and $x + \delta x$. For the steady state there is no accumulation (plus or minus) of neutrons in the element, so that the equilibrium condition is that: (number of neutrons diffusing into the element per second) minus (number of neutrons diffusing out of the element per second) plus (number of neutrons born per second within the element) is equal to (number of neutrons absorbed per second within the element). This is the condition for criticality, that is for a steady-state (non-diverging, non-converging) chain reaction to proceed. The source term $k_\infty \Sigma_a (n v)\ \delta x$ comes directly from the definition of k_∞ (Fig. 13) together with the absorption term, since k_∞ neutrons are born for each neutron absorbed within the system.

Critical Equation (*Fig.* 23).—The condition for a steady-state self-sustaining chain reaction derived in the section referred to Fig. 22 gives rise to this second-order ordinary differential equation which is readily solved for the boundary conditions given and reveals a cosine distribution of neutron population density n. Since the neutron flux density is nv and v is constant, this curve is also the shape of the neutron flux density distribution. Notice particularly the quantity B which sometimes has a suffix, either m (material) or g (geometric). As written down in the derived equation B occurs naturally as a combination of physical properties of the material of which the reactor is composed and is therefore named B_m, the material buckling. But the reactor will not be critical unless B_m matches the value of B, namely B_g, required to satisfy the differential equation for the given boundary conditions, which value is determined solely by geometric considerations, and in this case has a value $\frac{\pi}{2a}$. If $B_m = B_g$ the reactor will be just critical. If $B_m > B_g$ the chain reaction will diverge, that is, the neutron population will increase. If $B_m < B_g$, the chain reaction will converge, that is the neutron population will decrease. Notice that B^2 is a direct measure of the curvature $\left(\frac{d^2n}{dx^2}\right)$, or buckling, of the neutron density distribution curve; hence the name.

Neutron Cycle in Finite-Sized One-Group Reactor (*Fig.* 24).—Fig. 14 can now be modified to take account of neutron leakage from the boundaries of the finite-sized reactor. It was seen that for a steady-state chain reaction the $(k_\infty - 1)n$ surplus neutrons per generation must either be absorbed or wasted by leakage. If the latter, then since the condition for criticality is that $B_g^2 = \frac{(k_\infty - 1)}{L^2}$, it is evident that the neutron leakage per generation must be $B_g^2 L^2 n$. The number re-entering the cycle is n, so that the the leakage fraction must be $\frac{B_g^2 L^2 n}{n + B_g^2 L^2 n} = \frac{B_g^2 L^2}{1 + B_g^2 L^2}$. Similarly the non-leakage fraction (the fraction of $k_\infty n$ absorbed in the reactor) is $\frac{1}{1 + B_g^2 L^2}$.

* * *

FUEL ELEMENT CONFERENCE

A review of fuel element fabrication practice and the behaviour of fuel elements in reactor operation have been the subjects of a conference held recently in Paris. Corrosion and irradiation were particular problems discussed. Attended by representatives of the O.E.E.C. countries, and Canada and Israel, the conference was sponsored by the French and United States atomic energy commissions.

MAIN-LINE DIESEL-ELECTRIC LOCOMOTIVE

B.R. Type 1

The first of ten 800 h.p. Bo-Bo Diesel-electric locomotives for main-line freight duty has recently been handed over to the British Transport Commission by the British Thomson-Houston Company, Limited, Rugby. The new locomotives are classified as Type 1 (formerly known as Type A) in the British Railways' Diesel range, and will bear the B.R. running numbers D8200-D8209. All the ten locomotives will be allocated to Devons Road Motive Power depot in the London Midland Region. They will work freight trains between Poplar, Temple Mills, Acton and Willesden.

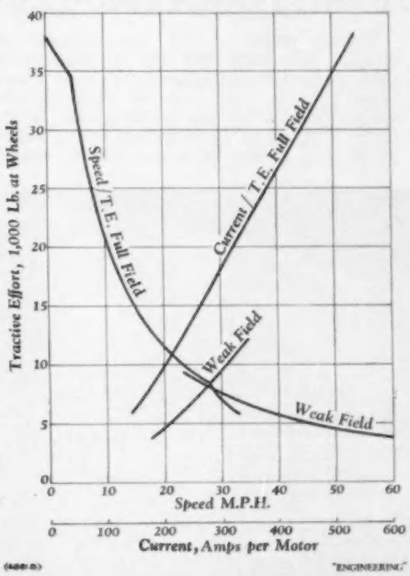


Fig. 1 Performance characteristic of the 800 h.p. B.R. Type 1 locomotive.

The B.R. Type 1 locomotive is rated at 800 h.p. It has a maximum designed speed of 60 m.p.h. and a maximum tractive effort of 37,500 lb. at starting; it is capable of exerting a continuous tractive effort of 20,000 lb. at 10·5 m.p.h., with a wheel diameter of 39 in. The length over buffers is 42 ft.; length over headstock, 38 ft. 6 in.; distance between bogie centres, 22 ft. 6 in.; bogie wheelbase, 8 ft. 6 in. The weight, in working order, is 68 tons; and the fuel tank capacity is 400 gallons. Fig. 2 shows the locomotive, with equipment compartment doors open; performance curves are given in Fig. 1.

The locomotive is of generally conventional design, two four-wheeled swing bolster bogies being used, with SKF roller bearing axleboxes. The bogies are fitted with spherical centre pivots which support the body weight and transmit tractive force; side bearers to limit rolling are provided. There is a nose-suspended force-ventilated traction motor mounted on each axle, driving through single reduction gearing with a resilient gearwheel. The body comprises a power unit and radiator compartment, a driver's cab, and a short rear compartment

Fig. 2 The main-line freight locomotive, with equipment compartment doors open.

Continuing **Design**

housing the control equipment and certain auxiliaries.

The power equipment consists of a Paxman 16-cylinder YHXL V-type Diesel engine rated 800 b.h.p. at 1,250 r.p.m., coupled to a B.T.H. six-pole 500 kW generator rated 690/337 volts, 720/1,320 amperes. The engine-generator set is resiliently mounted at four points on the two I-girder longitudinals which form the principal members of the underframe. The latter, which is of especially rigid construction, is illustrated in Fig. 3. The auxiliary generator is an eight-pole machine rated 40 kW, 110 volts, 625/1,250 r.p.m., the armature being carried on an extension of the main generator shaft. The exciter, a four-pole machine with separate, self and differential series excitation, is mounted on an adjustable platform on top of the auxiliary generator frame, and is belt-driven from the main generator shaft.

The main control gear is located in the short compartment behind the driver's cab, which is remote from engine fumes and heat, where it is free from contamination by oil or water, and is easy and convenient of access. The driver's cab has two driving positions, diagonally situated, at each of which a comfortable swivelling seat is provided; to the right of each position is located a free-standing master controller, incorporating essential indicators, and to the left are the air and vacuum brake controls. Other instruments and alarms are mounted on the cab bulkheads.

The locomotive is fitted with compressed air brakes, and with vacuum exhausters and control equipment for application of vacuum train brakes; it is arranged for operation in multiple with certain locomotives of similar or of greater rating in groups of up to three locomotives for handling heavy trains.

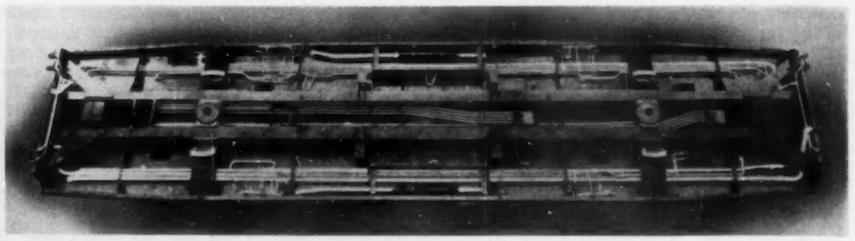


Fig. 3 The underframe, showing the layout of pipework, bogie pivots and side bearers.

The locomotive has been designed to the general requirements of the British Transport Commission under the overall direction of Mr. R. C. Bond and Mr. S. B. Warder (respectively Chief Mechanical Engineer and Chief Electrical Engineer, British Railways Central Staff, B.T.C.).

Mr. J. F. Harrison (Chief Mechanical and Electrical Engineer, L.M.R., Derby) has been responsible for liaison with the contractors and for inspection during construction and preliminary testing. Mr. John Barnes, F.S.I.A., of Allen-Bowden Limited, Leamington Spa, has acted as design consultant on behalf of the B.T.C. Design Panel. A feature of the styling is the well co-ordinated external appearance. Originally the ventilating louvres were located in the access doors, but in the final design the doors were made flush and the louvres arranged above in one continuous panel. At the same time other louvres and filter panels were re-arranged to harmonise with the general clean design, and the necessary grab rail is in aluminium to form an unpainted trim line.

The British Thomson-Houston Company, Limited, in addition to acting as main contractor for the whole locomotive, provided all the electrical equipment and carried out the erection and wiring of the equipment in the locomotive, and subsequent testing. The mechanical structure was designed by the Clayton Equipment Company, Limited, in close collaboration with the British Thomson-Houston Company, Limited. The bogies and the superstructure of the locomotive were built by the Clayton Equipment Company at their Tutbury Works. The underframe was built by the Yorkshire Engine Company, Limited, Sheffield, and the final assembly and painting of the complete locomotive were carried out by the same company. The Diesel engine was provided by Davey, Paxman and Company Limited, Colchester, who also undertook the coupling up of the generator unit.

TOWARDS A FULLY AUTOMATIC TELEPHONE NETWORK

Another step towards the automation of Britain's telephone network—and perhaps towards cheaper telephone calls—was taken on November 28, when field trials of a new electronic director, the first of its type to go into operation in the United Kingdom, were inaugurated at the Lee Green, London, automatic exchange by the engineer-in-chief of the Post Office, Sir Lionel H. Harris, K.B.E., T.D. The new equipment, when working at full capacity, will be able to route more than 100 calls simultaneously to different destinations. The Post Office's efforts towards increasing the efficiency and economy of the telephone service were outlined by Sir Lionel in his opening speech, from which some extracts are given in the following paragraphs.

In general, the various systems of automatic telephone switching providing service to most of the world's 110 million telephone subscribers have now reached a state as near perfection as is permitted by the electromagnetic methods which they employ. Many believe that electronic methods of switching will eventually lead to new levels of attainment, and will meet also the probable requirement of higher frequency operation of the cable network.

In Britain, since the war, the Post Office and manufacturers of exchange equipment have studied the problem; latterly, all have pooled their research and development resources in order to concentrate the effort and to avoid duplication. The firms concerned are the Automatic Telephone and Electric Company Limited, Ericsson Telephones Limited, General Electric Company Limited, Siemens Edison Swan Limited, and Standard Telephones and Cables Limited.

Various electronic and semi-electronic exchanges have been built and operated within these industrial organisations, but now a concerted effort is being made on the design of a system suitable for the public service of the future with all its complications. It is anticipated that a trial exchange will be opened early in 1960 at Highgate Woods which will provide information much beyond that which can be obtained in the laboratories.

The new electronic director equipment on field trial at Lee Green automatic exchange uses a magnetic drum, seen on the right, for storing numbers and translating them into routing instructions.

In addition to the development of complete exchanges the Post Office has been greatly interested in the development of electronic equipment forming part of, or ancillary to, the existing system. As early as 1952 electronic versions of " directors " which register, translate and route calls from exchange to exchange in our big cities were installed at Richmond. It soon became apparent that this early equipment was even more reliable than the electromagnetic versions which had by then been fully developed and improved over many years. Further extension at Richmond in 1954 confirmed this view. Electronic key senders installed at Thanet in 1955 have similarly proved successful. When Subscriber Trunk Dialling opens at Bristol in 1959, the register translators (GRACE) which will route the calls dialled at Bristol to the wanted subscribers in other cities will be completely electronic. Apart from filling a need in the development of the telephone service these innovations serve to introduce electronic techniques to the engineering staff. (A description of GRACE was published in ENGINEERING last week.)

In the field trial at Lee Green, magnetic drum techniques, developed in this case by the Automatic Telephone and Electric Company of Liverpool, replace in a comprehensive way the electromagnetic directors and other associated switches found normally in an exchange of this kind. The change is expected to increase reliability and economy.

MAGNETIC DRUM DIRECTOR

The new electronic equipment now in operation at the Lee Green Automatic exchange employs a magnetic drum storage unit for remembering numbers and translating them into routing instructions. Known as the magnetic drum director, it was developed by the Automatic Telephone and Electric Company Limited, Strowger House, 8 Arundel-street, London, W.C.2, and Strowger Works, Liverpool, 7.

The magnetic drum around which the new electronic director has been constructed consists of a bronze cylinder about 12 in. in diameter

and 3 in. deep. Its working surface is coated with approximately 0·0002 in. of nickel which forms the medium for the magnetic records. The records consist of sequences of magnetic "dots" which can be packed closely enough together to obtain 100 dots to the inch of circumference and at least ten similar circumferential "tracks" of dots to the inch axially. The total capacity of the drum is at least 110,000 dots. In operation, the drum rotates at about 1,800 r.p.m. and dots may be recorded or reproduced at a rate of about 100,000 dots per second.

The magnetic dots are coded into machine language to allow numbers and instructions to be built up in binary code; basically a four-dot pattern is adopted. Thus four dots are required to record a single digit, and seven sets of four dots are required to record a seven-digit number such as would be dialled by a caller.

The drum records are used in two ways. Some of the 30 tracks are used for remembering the translations likely to be required—about 700 in all. These records are virtually permanent in the sense that they are changed only when, for administrative reasons, it is necessary to alter a translation. The remainder of the tracks are used as control tracks; some provide the means for synchronising the operation of the complete equipment and others provide individual memories for switch control units, of which there are 114.

The electronic equipment associated with the drum contains a scanner, driven by the synchronising tracks, which, among other things, causes each switch control unit to be associated in turn with the particular portion of one of the tracks allotted to it. The switch-control memory tracks provide means for keeping a running record of the state of each control unit and by continuously checking this running record the electronic equipment can determine what action is next required in each case.

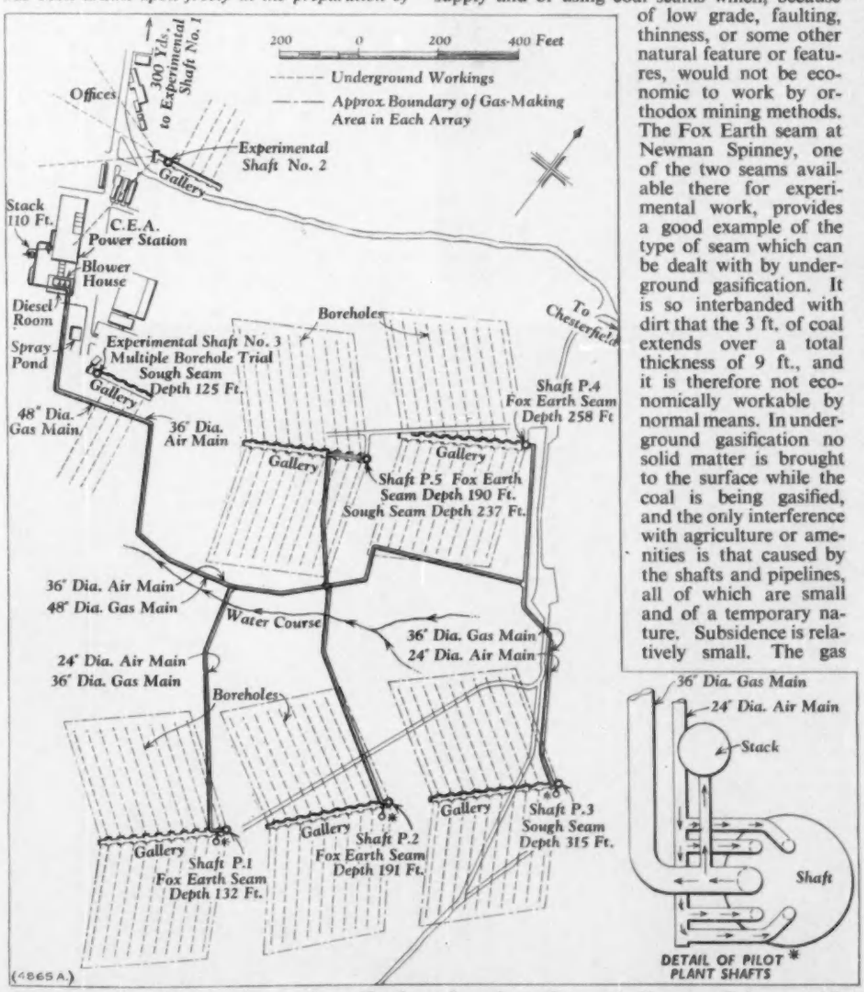
The running record is kept up to date merely by recording the most recent record in place of the old one. In this way the electronic equipment and the drum can be time-shared over 114 switch control units in as little as 17 milliseconds each without interfering with any other. Moreover, each of the 114 control units can be rescanned every 17 milliseconds so that changes of state of up to 60 changes per second are recognised. This permits considerable economies in apparatus and is one of the reasons for developing the trial equipment. The translation tracks are referred to whenever a switch control unit reaches an appropriate condition.

Production

UNDERGROUND GASIFICATION OF COAL

The possibility of gasifying coal underground was first suggested by Sir William Siemens in 1868, but no large-scale experiments were made until 1931, when field work, which has continued ever since, was started in Russia. In this country experiments began in 1949, and they are still in progress. An official publication described the British experimental work up to 1955, and a recent paper† by Mr. C. A. Masterman,‡ which has been drawn upon freely in the preparation of this article, has brought the subject up to date, with an account of the work done and in progress at Newman Spinney, near Chesterfield.*

The fuel position in this country is such that any additional source of power is welcome, provided that its production is both practicable and economic. Underground gasification offers the double advantage of supplementing the power supply and of using coal seams which, because of low grade, faulting, thinness, or some other natural feature or features, would not be economic to work by orthodox mining methods. The Fox Earth seam at Newman Spinney, one of the two seams available there for experimental work, provides a good example of the type of seam which can be dealt with by underground gasification. It is so interbanded with dirt that the 3 ft. of coal extends over a total thickness of 9 ft., and it is therefore not economically workable by normal means. In underground gasification no solid matter is brought to the surface while the coal is being gasified, and the only interference with agriculture or amenities is that caused by the shafts and pipelines, all of which are small and of a temporary nature. Subsidence is relatively small. The gas produced is of low calorific value—generally less than 100 B.Th.U. per cub. ft., but it is combustible, and an obvious way to use it is in electric power generation by orthodox steam plant. It is on these lines that the present experiments are proceeding.



Experimental work on underground gasification of coal continues at Newman Spinney, while preparations for a pilot scheme for electric power generation are proceeding at the five points shown (shafts P1 to P5).

FIRST TRIALS

Up to the middle of 1956 the experimental work was carried out by the Ministry of Fuel and Power, and two sites, with different seam conditions were used. Over 5,000 tons of coal were gasified, and after trying out several different techniques it was decided that one or more of them were practicable. For some years the main experimental work was based on working from the surface, and some success was achieved with the two principal methods tried, high-pressure linkage and electro-linkage, both of which opened up passages for air and gas in the coal seam between vertical boreholes. Linkages up to 50 yards were obtained, and on one occasion 800 tons of coal were gasified in a single trial. It was decided, however, that neither method was sufficiently reliable for commercial operation, and in 1953 the experiments were changed from the purely surface-operated kind to a type in which a certain amount of preparatory work is done by men working underground. This enabled boreholes to be put into the coal from galleries driven in the seam, and so provide a more positive means of controlling the flow of air and gas.

Considerable experience has now been gained in borehole drilling, and some important conclusions can be drawn from the information available. Preparatory work for drilling in the seam involves sinking shafts and driving galleries by normal mining methods, but the cost of so doing may well be less than that of the many vertical boreholes required for high-pressure or electro-linkage, particularly as the shafts need only be quite small. Consequently, the shaft and gallery method is favoured, and no great attention is being paid at present to the more revolutionary possibility of drilling vertically down to the seam, turning the borehole to run in the coal, and then turning it again vertically to reach the surface. Even if this development were technically possible it seems likely that it would be more expensive than using shafts and galleries. Given the necessary underground access to the seam, boreholes can be used in two different ways. They can be put through from one gallery to another, to enable the air for combustion to go in at one end and the gas

* "British Trials in Underground Gasification, 1949-1955." H.M.S.O. Code No. 41-134.

† "Recent Developments in Underground Gasification," by C. A. Masterman, O.B.E., M.A., F.R.I.C., M.I.Mech.E., M.Inst.Gas E., read to the North of England Institute of Mining and Mechanical Engineers, on October 5, 1957.

‡ Chief Technical Adviser (Underground Gasification), Humphreys and Glasgow, Limited.

Continuing Production

to be taken out at the other. Alternatively, they can be driven to a blind end, with no outside connection, and, the coal having been ignited at that end, air can be passed in through a core tube, and the gas drawn off in the space between the air tube and the borehole wall. Hot gases passing back along the borehole transfer much of their sensible heat to the ingoing air. It is this technique which is being used to-day

POWER GENERATION

One of the two original experimental sites, at Bayton, Worcestershire, has been closed, and work is now concentrated at Newman Spinney. Responsibility for underground gasification was taken over from the Ministry by the National Coal Board in 1956, and an extra 50 acres have been added to the original 23 acre site in preparation for further development work. In co-operation with the Central Electricity Authority work is now in hand for a pilot system able to produce gas in sufficient quantity to generate 5 MW continuously for several years, beginning next year. This installation, about one-tenth the size of the smallest commercial scheme, will enable further data to be accumulated for the design of a full-scale scheme. In particular, it will provide a basis for determining costs and will give technical information on plant operation.

In 1957 the Coal Board appointed Humphreys and Glasgow, Limited, 22 Carlisle-place, London, S.W.1, as their contractors for the construction of the pilot plant up to the gas inlet of the C.E.A. power station, which is to be built at Newman Spinney. Humphreys and Glasgow are also responsible for further experimental and development work, and for the design of a gasification layout based on the commercial production of 60 MW of electricity. Sir Alexander Gibb and Partners are acting as the Board's consultants on the Newman Spinney project, in co-operation with Cremer and Warner, consulting chemical engineers.

BLIND BOREHOLE TECHNIQUE

The practicability of the blind borehole technique has been established beyond doubt, but much experimental work requires to be done to clear up various technical problems. It is necessary, for example, to use a special drilling technique to ensure that the borehole proceeds in the required direction and inclination, and to deflect the hole as required, either to correct an error, or to follow a change in seam inclination. Boreholes run out of the required line from time to time, and fail to respond to correction, and experimental work is still in progress to find the answers to these problems, and to obtain satisfactory costs and speeds of drilling. To avoid possible interference with gasification trials at Newman Spinney, the Coal Board have provided facilities for experimental directional drilling at the nearby Oxcroft Colliery, and this work is now concentrated there.

In its essentials the blind borehole technique is simple. When the borehole has been drilled to the required length an air pipe is inserted in it, together with a small pipe carrying at the inbye end an electrically-ignited firework of the flare type in a waterproof container. The ignition of the coal is by means of this firework and propane or other gas fed up the small tube for a sufficient length of time to enable the coal reaction to become established. Possible dimensions for the borehole are: length, 300 ft.; diameter, 12 in.; air pipe, 4 in. diameter. Mild steel tube has been used for the air supply, but experiments are in progress with high-chromium cast-iron tube, sleeved at the forward end with refractory material to protect it against excessive temperature and corrosion. For obtaining experimental data in a single borehole trial, instruments are provided on the surface for recording temperature, calorific value, gas constituents (including moisture content), specific gravity, air and gas flow and pressure and water level in the sump. This instrumentation is supported by manual determination of gas analysis and other factors. It is emphasised that this extensive instrumentation is not necessarily required for each borehole in a multi-borehole trial, and even less for a commercial system.

SOME TRIAL RESULTS

So far, the experiments at Newman Spinney have been confined to single borehole work, though a multi-borehole trial is in course of preparation, and this technique will be used for the pilot power generation layout.

Shaft No. 1 has a single blind borehole, 178 ft. long, with a high-chromium iron air pipe 2¾ in. bore, protected by refractory pipes over the inbye 70 ft. Ignition took place on July 2, 1957, the trial being primarily intended to test the suitability of the high-chromium iron air pipe. A severe leak developed in the air pipe on November 10, and the experiment had to be terminated. The air leak was through a fracture in the air pipe at the cool end, probably caused by thermal movement of the pipe as a whole. In future experiments the gallery end of the pipe will be left free to expand, and so the stresses imposed on it will be reduced.

In Shaft No. 2, a single blind borehole experiment with a mild-steel air tube, protected throughout with refractory piping, was concluded earlier this year, and some of the piping has been extracted and brought to the surface for examination. Vertical drilling from the surface after the gasified area had been extinguished showed a regular pattern of reaction, with an overall width of between 27 and 29 ft. It also showed that the experiment, which had run for some five months, could pr bably have gone on for as long again. Further experiments on air pipe are being carried out in "trench" tests at the surface, where batches of about 20 tons of coal, compacted into a trench and completely covered, are gasified through a dummy borehole in a manner which simulates as nearly as possible the conditions underground. Each test lasts four or five days, and the lid of the trench is then lifted and the pipe taken out for examination.

Holes drilled in the coal seam from an underground gallery are first reamed to the required diameter—in this case 12½ in.

Air tubes in short lengths are inserted into the boreholes and coupled, with airtight joints, into a continuous length. An air tube is seen on the right of the picture, together with the borehole capping.

Constant readings of temperature are taken by means of thermocouples at various points during the test, and the conditions which the pipe has had to withstand are therefore known with considerable accuracy.

MULTIPLE BOREHOLES

Final preparations are now being made for the first multiple borehole trial, for which a shaft has been sunk 125 ft. to the Sough seam, the second of the two available at Newman Spinney. Four boreholes, each 250 ft. long and 12½ in. in diameter, have been driven in the seam at 10-yard spacing. The air pipes are of high-chromium cast iron made up of short lengths suitable for sending down the small shaft, and joined *in situ* by cast threads on the pipes and screwed couplings. A special refractory material in paste form is used, together with asbestos ring gaskets, to ensure an airtight joint. As each length of pipe is screwed home a hydraulic ram, operated by a small electric pump and taking its thrust against the back of the drilling bay, is used to push the pipe into the borehole. Refractory piping protection is provided on the inbye 70 ft. of each air pipe.

In this experiment, for the first time, the gallery and shaft will be used to conduct the gas to the surface, and it will be possible to leave the gallery end of the air pipes free to expand, so reducing the stresses imposed by expansion. Water sprays have been arranged to cool the gas to 35 deg. C. at the shaft top. The experiment will provide information on the behaviour of multiple boreholes, which will be of value in the next stage, the firing of the pilot system for electric power generation.

GAS FROM SEVERAL SHAFTS

The pilot system, on which work is now in progress, is scheduled to be producing gas by December, 1958. It will consist of a number of sections or "arrays," each having an 8 ft. diameter shaft and a gallery 100 yards long, with ten boreholes 100 yards long drilled on each side from bays spaced at 10 yard intervals. Each section will thus cover an area of about 20,000 square yards of coal seam.

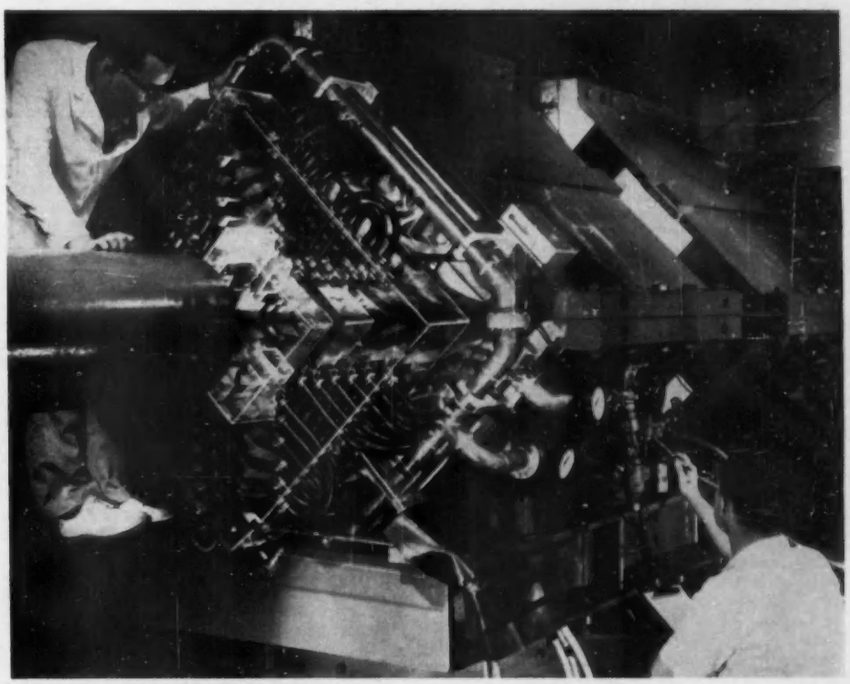
At present there are five arrays in course of preparation, as shown on the site plan reproduced herewith. Shaft sinking and the driving of galleries is being undertaken as a sub-contract by the Cementation Company, Limited, Doncaster, and this work is now in its early stages.

Two arrays operated simultaneously will provide the desired gas output of about 1 million cub. ft. per hour, and at this rate of production they will have a working life of about six months. Fresh arrays will be brought into production as the original ones become exhausted. Air will be taken from a central blower house via mains up to 36 in. in diameter to the shaft tops at a maximum pressure of 10 lb. per sq. in., and thence by ducting and manifold to the borehole air tubes. Gas mains up to 48 in. in diameter will take the gas to the power station, and a booster in the gas line will maintain a negative pressure in the galleries. Gas and air may be pre-heated with chimney heat at the power station.

Atomic Review

Waves or Particles

THE atomic nucleus is still in many ways a mystery. Though it may be looked upon for some purposes as a group of particles, these particles do not have the solid and continuous existence that we associate with a billiard ball; for other purposes the nucleus may more conveniently be understood in terms of wave motions. Certain nuclear entities—the neutrino for example—seem, at least to the lay mind, little more than intellectual evasions. The character of the nucleus is a subject on which much study is at present being concentrated. The fruits of this study may be unexpectedly rewarding and their nature unforeseen. The following notes are concerned largely with research of this kind and the techniques employed in its pursuit. The complexity of the necessary apparatus may be gathered from the illustration on the right, which shows a device for focusing meson beams emitted by the Brookhaven Cosmotron.



Device for focusing beams of mesons emitted from the Cosmotron at Brookhaven, U.S.A.

Soviet Nuclear Research

Information concerning the Joint Nuclear Research Institute at Dubna near Moscow was published in Atomic Review last November 22. Professor Vaclav Votruba, vice-director of the Institute, in an interview with a representative of ENGINEERING, stated that research workers were expected to prepare their results in both Russian and English—though generally speaking, only the theoretical physicists had a sufficient command of English to do so.

Nine recent research reports (eight of which are available in English) issued by the Institute are devoted to the following subjects: nuclear matter fluctuation (D. I. Blokhintsev); displacing deuterons from nuclei of lithium, beryllium, carbon and oxygen, using protons with energies of 675 MeV (M. Meshcheryakov and others—in Russian); increasing the density of an external proton beam from a 6 metre synchro-cyclotron (V. I. Danilov and others); mesonium and anti-mesonium (B. Pontecorvo); conservation of combined parity in strong, electromagnetic and weak interactions (V. G. Soloviev); statistical weight of a system of particles with arbitrary spins (V. S. Barashenkov and B. M. Barbashev); inversions of space and time (J. Rzewuski); reverse dispersion relations (V. Blank and D. Shirkov); and the spin of the Λ^0-particle (M. I. Shirokov). Certain of these reports are summarised below.

Nuclear Matter Fluctuation

In a report by Academician D. I. Blokhintsev, director of the Institute, it is shown that the appearance of energetic fragments following the collision of fast nucleons with nuclei may be considered a result of the interaction of a nucleon with the fluctuation of nuclear matter. During the motion of nucleons within the nucleus short compact clusters of nuclei may be formed, in other words there is a fluctuation in the density of the nucleus. Being comparatively separate from the other nucleons of a nucleus, such clusters may be regarded as atomic nuclei of lesser mass in a state of fluctuating compression.

Recently, while studying the scattering of 675 MeV protons on light nuclei, M. G. Meshcheryakov and his colleagues at Dubna discovered phenomena which confirm the existence of such fluctuations, at least for the simplest pair fluctuations, leading to the formation of the compressed deuteron. Attention has already been drawn to the formation of fragments with higher energy than the potential barrier during collisions (fission) of nuclei with energetic nucleons, that is fragments with an energy of motion considerably higher than the combined binding and barrier energies of a nucleon. However, the absence of quantitative data impeded the analysis of these phenomena, which were explained in terms of hypothetical long-range nuclear forces; or paired nuclear forces.

The experimental data concerning the emergence of energetic deuterons from light nuclei confirm that other fragments with energy higher than the potential barrier are also formed as a result of direct collision of a nucleon with a compact group of nucleons, which has arisen owing to fluctuation in density of the nucleus. In the report, further quantitative arguments for fluctuational origin of energetic deuterons and other fragments with energy higher than the potential barrier are advanced.

In experiments on 675 MeV protons scattered by deuterons, in addition to the scattered nucleons, undestroyed deuterons of high energy (about 660 MeV) have been observed, though relatively few of them. It follows that during those collisions a nucleon transfers to a deuteron an important part of its momentum. According to the idea of fluctuation such a collison takes place at the moment when both of the nucleons within a deuteron are a short distance R apart and consequently they interact very strongly. In such a case it is possible for a nucleon to transfer its momentum to this close pair as a whole. The expected cross-section for such

Continuing Atomic Review

special collision is given by the equation:

$$\sigma = \sigma_d W_d(R)$$

where σ_d is the full quasi-elastic collision cross section, and $W_d(R)$ the probability that both of the nucleons of a deuteron are at a distance less than R.

Mesonium and Antimesonium

It has been pointed out that K^0 and anti-K^0 particles are not identical. The possibility of K^0 and anti-K^0 transitions induced by weak interactions makes it necessary to consider neutral K mesons as a mixture of particles of different (combined) parity (K_1^0 and K_2^0). A report by B. Pontecorvo discusses the problem as to whether there exist other " mixed " neutral particles (not necessarily " elementary " ones) which are not identical to the corresponding antiparticles and for which particle—antiparticle transitions are not strictly forbidden.

The number of possible mixed neutral systems is strongly limited by conservation laws for the number of barions and light fermions (conservation of nuclear and neutrino charges). According to the first law mixed particles cannot exist among barions (for instance, neutron, hydrogen atom) and due to the second law such particles cannot exist among systems of light particles with only one fermion (for example, neutrino Π^+e^- and Π^-e^+ systems. It apparently follows that mesonium defined as the bound system (μ^+e^-) is the only mixed particle of interest existing (in addition to the K^0 meson) among already well-known systems. Antimesonium, that is, the system (μ^-e^+) obviously differs from mesonium; in addition, mesonium—antimesonium transitions not only are not forbidden by any known law but, what is more, they must take place due to known interactions.

Scattering Matrix for Two-Nucleon System

The number of experiments necessary for determining the elements of the elastic scattering matrix is discussed in a report by L. Puzikov, R. Ryndin and Ya. Smorodinsky. It is shown that the required number of experiments equals the number of complex functions entering the scattering matrix. In the case of nucleon-nucleon scattering the elastic matrix can be determined on the basis of five experiments: measurement of the cross-section, polarisation, normal component of the polarisation correlation tensor, and the normal components of the triple scattering tensor (for both particles). It is shown that experiments with rotation of polarisation by the external magnetic field are not necessary for phase-shift analysis.

Cold Fusion

What were believed to be fusion reactions were observed in liquid hydrogen during experiments carried out last year at the University of California. The subject was discussed in Atomic Review last January 11. The reactions depended on the introduction of a catalytic particle—the negative μ meson. Unfortunately this particle was short lived, and if the cold fusion reaction was to be useful a similar but longer-lived particle would be necessary. It was reported at the time that a Soviet physicist Alikhanian had postulated the existence of such a particle. In an interview with a representative of this journal, Professor Votruba said that although Alikhanian was sometimes optimistic, it had proved very difficult to discredit this particular conclusion. Indeed, the decision had been taken to perform an experiment at Dubna to test the validity of Alikhanian's results; Professor M. Danysz was designing a suitable experiment using one of the Institute's accelerators.

Cambridge Electron Accelerator

President James B. Killian of Massachusetts Institute of Technology and President Nathan M. Pusey of Harvard University, have recently performed a ceremony initiating construction of the Cambridge Electron Accelerator. Scientists at M.I.T. and Harvard are co-operating in the design and operation of the new 6,500,000 dols. machine, which, it is claimed, will produce the highest-energy electrons in the world. Construction is expected to take more than two years. Initial operations of the new accelerator are planned for January, 1960. The ceremony took place at the site which is near the Harvard Cyclotron Laboratory.

The new accelerator will be devoted to basic, unclassified research on the properties of the sub-nuclear particles and of the forces which hold the nucleus together. It will be located near the Harvard Cyclotron. The machine—a synchrotron—will accelerate electrons to very nearly the speed of light and in the process will increase their mass by 12,000 times. At this speed, the electrons and the super-energy X-rays which they produce will be able to disrupt protons and neutrons. The circular tunnel building for the accelerator will be placed below ground, sheathed in concrete and with a 5 ft. earth-fill over the top. Heavy concrete blocks forming a portion of the wall can be arranged to allow narrow beams of radiation to emerge from the synchrotron into the large experimental building where research experiments will be located.

The synchrotron will comprise a ring of magnets arranged in a circle 236 ft. in diameter. The magnets will use the recently developed strong-focusing principle to retain the electrons in an oval vacuum chamber 6 in. wide and 2 in. high while being accelerated around the ring. Focusing is accomplished by alternation of the shape of the magnet pole faces from one magnet to the next. Forty-eight magnets will be used, each about 11 ft. long and composed of thousands of thin steel laminations. The magnets are laminated to reduce heat and energy loss while being pulsed 30 times per second.

The electrons will be accelerated initially in a linear accelerator which uses microwave radar techniques. A pulse of electrons from the linac will be injected into the synchrotron 30 times per second, timed when the magnetic field is low. As they circle through the tubular vacuum chamber they will traverse 16 radio-frequency circuits spaced around the ring, receiving an accelerating " kick " each time they pass through a circuit. Power equivalent to that of a television transmitter will be supplied to each circuit through radar-type waveguides from a central radio-frequency power station. The electrons will whirl around the synchrotron for one-sixtieth of a second, during which time the magnetic field rises to its peak value, making 20,000 revolutions and receiving 320,000 kicks from the electrical circuits.

Strangeness

With the tremendous energy developed in the Cambridge Electron Accelerator, just beginning construction, physicists will be able to study the fundamental forces underlying the structure of protons and neutrons. Dr. M. Stanley Livingston, Professor of Physics at the Massachusetts Institute of Technology, who is in charge of the project, has explained the nature of the studies to be undertaken. It is already known that many unstable forms of matter will be produced. Physicists regard particles as states of matter. Some of their properties such as mass, energy, and spin can be identified. But particles are being found which differ in some other property, at present completely unknown and called "strangeness;" they are therefore called "strange" particles. Particles like the negative proton and the anti-neutron do not fit the patterns of present theory. A positive proton and a negative proton may have equal mass and equal and opposite charge, but they combine with tremendous energy release when they come together. The new synchrotron should produce heavy mesons, negative protons, and other new, unstable particles in larger numbers and with higher energies than existing accelerators.

Spiral-Ridge Synchrotrons

The effect on betatron oscillations of introducing straight sections into a spiral-ridged synchrotron is discussed in a recent report. Formulae are developed and shown to agree with direct computations. In particular, it is shown how for the proposed synchrotron at the National Institute for Research in Nuclear Science, the combination of weak radial focusing and fairly strong vertical focusing leads to the phenomenon of multiple closed orbits and also to wide variations of frequency of oscillation about these closed orbits. (M. J. Mitchell and D. Morgan: AERE TP/R 2175.

First Director of Rutherford Laboratory

The Governing Board of the National Institute for Research in Nuclear Science announce that they have appointed Dr. T. G. Pickavance as Director of the Institute's High Energy Laboratory at Harwell. Dr. Pickavance is at present deputy head of the General Physics Division of the Atomic Energy Authority's Research Establishment at Harwell. The laboratory is to be called the Rutherford High Energy Laboratory to commemorate the work of the late Lord Rutherford in the development of nuclear physics. It is being built on a site adjacent to the Atomic Energy Research Establishment and will house the Institute's first large accelerator, a research machine of which the main part is a magnet ring 120 ft. in diameter weighing over 6,000 tons.

General Notes

More Reactor Courses at Harwell

The Reactor School at Harwell is to increase the number of courses to be held each year. Four standard courses will be held instead of three, each lasting 16 weeks, and there will also be two courses for senior technical executives each lasting nine days. The fee for a standard course is £250 and for a senior technical executives' course £50. These fees do not include accommodation, although the Authority will be ready to assist in making bookings. The dates of the courses are, for the standard courses: January 13 to May 8, 1958, April 14 to August 1, September 1 to December 23, and October 27 to February 20; and for the senior technical executives' courses: May 12 to May 22, and September 22 to October 2. Further details may be obtained from the Principal, Reactor School, Atomic Energy Research Establishment, Harwell, Didcot, Berkshire. The latest time for applications is 3 months before a course begins; the January course is already full.

Inquiry on Welsh Nuclear Power Station

The Minister of Power has decided to hold a public local inquiry into a proposal of the Central Electricity Authority to build a nuclear power station at Trawsfynydd in North Wales

American Group to Build LMFR

The formation of a new group, the American Nuclear Power Associates, consisting of private industrial and utility companies has recently been announced. Members of the group who have joined to date are Burns and Roe, Incorporated (architect-engineers), New York City; Clark Brothers Company, division of Dresser Operations, Incorporated (compressor and blower manufacturers), Olean, N.Y.; Griscom-Russell Company, subsidiary of General Precision Equipment Corporation (heat-exchange equipment manufacturers), Massillon, Ohio; Rockland Light and Power Company, Nyack, N.Y.; and Raytheon Manufacturing Company, Waltham, Mass. The purpose of the new group is the initial design of a novel high-temperature, high-performance nuclear power plant. The power plant will be based on Raytheon Manufacturing Company's liquid-metal-fuel gas-cooled reactor concept. The group's engineering team will be located at the Raytheon research laboratories in Waltham, Mass.

Aquilon in France

Contrary to the impression given in Atomic Review on August 9 (page 189), the reactor Aquilon diverged on August 11, 1956.

NOTICES OF MEETINGS

Association of Supervising Electrical Engineers

LONDON
"Electrical Floor Warming," by W. F. Parker. Institution of Electrical Engineers, Savoy-place, Victoria-embankment, W.C.2. Thurs., Dec. 19, 6.30 p.m.*

British Computer Society

LONDON
"Parallel Programming: A Study of a New Technique in Digital Computer Programming," by Dr. S. Gill. Northampton College of Advanced Technology, E.C.1. Mon., Dec. 16, 6.15 p.m.

British Institution of Radio Engineers

LONDON
"Recent Developments in Electronic Instrument Design," by E. Garthwaite and A. G. Wray. London School of Hygiene and Tropical Medicine, Keppel-street, W.C.1. Wed., Dec. 18, 6.30 p.m.*

Diesel Engineers and Users Association

LONDON
Presentation of "Report on Heavy Oil Engine Working Costs and Performance, 1956-57," and Discussion on "Operating Problems." Caxton Hall, off Victoria-street, S.W.1. Thurs., Dec. 19, 2.30 p.m.

Illuminating Engineering Society

BIRMINGHAM
"New Light Sources," by F. Jackson. Birmingham Centre. Regent House, St. Phillip's-place, Colmore-row, Birmingham. Fri., Dec. 20, 6 p.m.
LIVERPOOL
"Lighting and Coal Mining," by W. E. Mangnall. Liverpool Centre. Liverpool Passenger Transport Office, 24 Hatton-garden, Liverpool 3. Mon., Dec. 16, 6 p.m.
MANCHESTER
"Lighting for Photography," by R. W. Unwin. Manchester Centre. Offices of the North Western Electricity Board, Town Hall, Manchester 2. Thurs., Dec. 19, 6 p.m.*

Incorporated Plant Engineers

BLACKBURN
"Some Aspects of Boiler Inspection," by W. A. Mills. Blackburn Branch. Golden Lion Hotel, Blackburn. Thurs., Dec. 19, 7.30 p.m.
ROCHESTER
"An Application of Incentives to Boiler House Operations," by K. Bentley. Kent Branch. King's Head Hotel, High-street, Rochester. Wed., Dec. 18, 7 p.m.

Institute of Fuel

LONDON
"Russian Coal Mining and Fuel Technology," by Dr. W. Idris Jones. Institution of Civil Engineers, Great George-street, S.W.1. Thurs., Dec. 19, 5.30 p.m.*

Institute of Marine Engineers

KINGSTON-UPON-HULL
"Trials and Maiden Voyage of the Gas Turbine Ship John Sergeant," by Dr. Ing. J. J. McMullen. Kingston-upon-Hull and East Midlands Section. Royal Station Hotel, Kingston-upon-Hull. Mon., Dec. 16, 7.30 p.m.
NEWCASTLE-UPON-TYNE
"Trials and Maiden Voyage of the Gas Turbine Ship John Sergeant," by Dr. Ing. J. J. McMullen. North East Coast Section. Stephenson Building, King's College, Claremont-road, Newcastle-upon-Tyne. Wed., Dec. 18, 6.15 p.m.*

Institute of Metals

BIRMINGHAM
Christmas Lecture for School Children, by Dr. E. C. Rhodes. Birmingham Local Section. Physics Department, The University, Edgbaston, Birmingham. Tues., Dec. 17, 2.30 p.m.

Institute of Packaging

LIVERPOOL
"The Contribution Made in the Packaging Field by the Packaging Consultant and Designer," by T. E. Preston. Merseyside Branch. Bradford Hotel, Tithebarn-street, Liverpool. Mon., Dec. 16, 6.30 p.m.
SLOUGH
Films on "Packaging Methods." Thames Valley Branch. Reindeer Inn, Slough. Wed., Dec. 18, 7.30 p.m.

Institute of Road Transport Engineers

LONDON
"Various Trends in Machining and Inspection Methods Concerning the Manufacture of Heavy Commercial Vehicles," by R. P. Chilton. Royal Society of Arts, John Adam-street, Adelphi, W.C.2. Thurs., Dec. 19, 6.30 p.m.*
LEEDS
"The Design of Vehicles for the Conveyance of Petroleum Products," by J. Bellwood. Yorkshire Centre. Great Northern Hotel, Wellington-street, Leeds 1. Thurs., Dec. 19, 7.30 p.m.

Institution of Chemical Engineers

MANCHESTER
"Chemical Engineering Aspects of Gas-Solid Reactions," by Professor K. G. Denbigh. North Western Branch. Reynolds Hall, College of Science and Technology, Manchester. Tues., Dec. 17, 7 p.m.

Institution of Civil Engineers

LONDON
Graham Clark Lecture: "The Engineer and Management," by Sir Ewart Smith. Joint Meeting with the **Institutions of Electrical Engineers** and of **Mechanical Engineers**. Tues., Dec. 17, 5.30 p.m.*

Institution of Electrical Engineers

LONDON
"Electronics and Automation: Electronics in the Textile Industry," by K. J. Butler. Radio and Telecommunication Section. Mon., Dec. 16, 5.30 p.m.*
"Recent Uses of Ultrasonics for Investigating the Characteristics of Materials," by Dr. J. Lamb. Measurement and Control Section. Tues., Dec. 17, 5.30 p.m.*
"The Planning and Construction of Large Modern Thermal Generating Stations," by J. Pimpaneau. Supply Section. Wed., Dec. 18, 5.30 p.m.*
BIRMINGHAM
Faraday Lecture on "The Electrification of the British Railways," by G. H. Fletcher. South Midland Centre. Town Hall, City of Birmingham. Mon., Dec. 16, 6 p.m.
CHESTER
"Electrical Floor Warming," by J. W. Moule and W. M. Stevenson. Mersey and North Wales Centre. Town Hall, Chester. Mon., Dec. 16, 6.30 p.m.
EDINBURGH
"Ship Stabilisation: Automatic Controls, Computed and in Practice," by J. Bell. South East Scotland Sub-Centre. Carlton Hotel, North Bridge, Edinburgh. Tues., Dec. 17, 7 p.m.

Institution of Engineers and Shipbuilders in Scotland

GLASGOW
"Free-Piston Progress," by F. A. I. Muntz and M. Barthalon. Tues., Dec. 17, 6.30 p.m.*

Institution of Heating and Ventilating Engineers

GLASGOW
"Choice of Fuels: Their Characteristics and Availability," by Dr. E. A. C. Chamberlain. Scottish Branch. Scottish Building Centre, 425 Sauchiehall-street, Glasgow, C.2. Tues., Dec. 17, 7 p.m.
NEWCASTLE-UPON-TYNE
"Intermittent Heating of Buildings," by E. Harrison. North East Coast Branch. Neville Hall, Westgate-road, Newcastle-upon-Tyne. Tues., Dec. 17, 6.30 p.m.
SHEFFIELD
"Some Aspects of Industrial Radiant Heating," by P. A. Coles. Yorkshire Branch. Royal Victoria Station Hotel, Sheffield. Wed., Dec. 18, 7.30 p.m.

Institution of Locomotive Engineers

LONDON
"American Experience as a Guide to Main Line Locomotive Applications Overseas," by H. G. McClean. Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, S.W.1. Wed., Dec. 18, 5.30 p.m.*

Institution of Mechanical Engineers

LONDON
Graham Clark Lecture: "The Engineer and Management," by Sir Ewart Smith. Joint Meeting with the **Institutions of Civil Engineers** and of **Electrical Engineers**, at the Institution of Civil Engineers, Great George-street, S.W.1. Tues., Dec. 17, 5.30 p.m.*
Steam Group Discussion. Wed., Jan. 1. (*Cancelled.*)
BIRMINGHAM
Discussion on "Miniature Cars in Britain." Birmingham A.D. Centre. James Watt Memorial Institute, Great Charles-street, Birmingham. Tues., Dec. 17, 6.30 p.m.
CARDIFF
"The Design and Operation of Flying Shears," by R. Stewartson. South Wales Branch. South Wales Institute of Engineers, Park-place, Cardiff. Tues., Dec. 17, 6 p.m.
GLASGOW
"Vehicle Characteristics and Their Relationship to Road Layout," by G. Grime. Scottish A.D. Centre. Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank-crescent, Glasgow, C.2. Mon., Dec. 16, 7.30 p.m.

Institution of Mining and Metallurgy

LONDON
"Lime Addition and Pulp Consistency in Gold Ore Mining," by G. Chad Norris; and "The Operation of the Iron Ore Company of Canada," by A. Choubersky. Geological Society, Burlington House, Piccadilly, W.1. Thurs., Dec. 19, 5 p.m.*

Institution of Naval Architects

LONDON
Amos Ayre Lecture: "The Evolution of the Cargo Ship During the Last 35 Years, and Some Thoughts on the Years to Come," by R. Ramsay Gebbie. Thurs., Jan. 9, 4.45 p.m.*

Institution of Production Engineers

BELFAST
"Spark Erosion Technique," by E. Foster. Northern Ireland Section. Kensington Hotel, Belfast. Thurs., Dec. 19, 7.30 p.m.
GLASGOW
"Men and Machines," by J. E. Hill. Glasgow Section. Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank-crescent, Glasgow, C.2. Thurs., Dec. 19, 7.30 p.m.
NEWCASTLE-UPON-TYNE
Exhibition of Films. Newcastle-upon-Tyne Section. Neville Hall, Westgate-road, Newcastle-upon-Tyne. Mon., Dec. 16, 7 p.m.

Institution of Structural Engineers

MANCHESTER
"A Review of the Structural Steelwork in the 'Seraphim' Extensions at Appleby-Frodingham," by S. Richards and N. Lancaster. Lancaster and Cheshire Branch. College of Science and Technology, Manchester. Mon., Dec. 16, 6.30 p.m.*

Institution of Works Managers

LIVERPOOL
"The Law of Master and Servant," by T. Gore. Merseyside Branch. Adelphi Hotel, Liverpool. Tues., Dec. 17, 6.30 p.m.

Junior Institution of Engineers

LONDON
"Use of Computers in Industry," by W. V. Barton. Fri., Dec. 20, 7 p.m.*

Non-Destructive Testing Society

LONDON
"Report of Second International Meeting on Non-Destructive Testing, Held in Chicago," by C. Campkin. 32 Welbeck-street, W.1. Fri., Dec. 20, 7 p.m.

Physical Society

LONDON
"Sound Insulation," by H. J. Purkis. Acoustics Group. Physics Department, Imperial College, South Kensington, S.W.7. Thurs., Dec. 19, 6 p.m.

Plastics Institute

LONDON
Chairman's Lecture on "The Plastics Institute, the Press and Industry," by C. W. Welch. London Section. Wellcome Building, 183-193 Euston-road, N.W.1. Tues., Dec. 17, 6.30 p.m.

Reinforced Concrete Association

BIRMINGHAM
"Some Reinforced Concrete Works in Europe and Asia," by N. A. Sadleir. Midland Counties Branch. Birmingham and Midland Institute, Paradise-street, Birmingham. Tues., Dec. 17, 6 p.m.*

Royal Aeronautical Society

LONDON
"Comparison of Ducted Fan, By-pass and Straight Jet Engines," by Dr. S. G. Hooker. Tues., Dec. 17, 7 p.m.

Royal Meteorological Society

LONDON
Various short papers. Wed., Dec. 18, 5 p.m.*

Royal Society of Arts

LONDON
"Sir George Cayley (1773 to 1857): A Pioneer of Science and Engineering." Wed., Dec. 18, 2.30 p.m.

Royal Statistical Society

LONDON
"The Depreciation and Mortality of Motor Cars," by J. S. Cramer. London School of Hygiene and Tropical Medicine, Keppel-street, W.C.1. Tues., Dec. 17, 5.15 p.m.*

Scientific Film Association

LONDON
Discussion on "Icicolor: The I.C.I. Negative-Positive Colour Process." Royal Photographic Society, 16 Princes-gate, S.W.7. Thurs., Jan. 2, 7 p.m.

Sheffield Metallurgical Association

SHEFFIELD
Film Evening. B.I.S.R.A. Laboratories, Hoyle-street, Sheffield. Tues., Dec. 17, 7 p.m.

Société des Ingénieurs Civils de France (British Section)

LONDON
"The Planning and Construction of Large Modern Thermal Generating Stations," by J. Pimpaneau. Joint Meeting with the Supply Section of the Institution of Electrical Engineers, at the headquarters of that Institution, Savoy-place, Victoria-embankment, W.C.2. Wed., Dec. 18, 5.30 p.m.*

Society of Chemical Industry

LONDON
Discussion on "Existing Facilities for Training in Corrosion Science," opened by L. W. Stubbs, at 2.30 p.m.; and Discussion on "Future Requirements for Teaching Corrosion Science," opened by Dr. T. P. Hoar, at 4.45 p.m. Corrosion Group. Wed., Dec. 18.

Society of Instrument Technology

LONDON
"Predicting the Reliability of Complex Machines," by Dr. G. Morris, A. J. Jones and W. W. Wright. Manson House, 26 Portland-place, W.1. Tues., Dec. 17, 7 p.m.*
NEWCASTLE-UPON-TYNE
"Nuclear Instrumentation," by T. R. Thompson. Newcastle Section. Stephenson Building, King's College, Newcastle-upon-Tyne. Wed., Dec. 18, 7 p.m.

West of Scotland Iron and Steel Institute

GLASGOW
"Electric Melting Furnaces," by F. S. Leigh. Fri., Dec. 20, 6.45 p.m.

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. Particulars for this column should reach the Editor not later than Monday morning in the week preceding the date of the meeting.

* An asterisk is placed where it is understood that tea is available prior to the time stated.

Association of Supervising Electrical Engineers, 23 Bloomsbury-square, London, W.C.1. (LANgham 5927.)
British Computer Society, 29 Bury-street, St. James's, London, S.W.1.
British Institution of Radio Engineers, 9 Bedford-square, London, W.C.1. (MUSeum 1901.)
Diesel Engineers and Users Association, 19 Old Queen-street, London, S.W.1. (TRAfalgar 5997.)
Illuminating Engineering Society, 32 Victoria-street, London, S.W.1. (ABBey 5215.)
Incorporated Plant Engineers, 12 The Parade, Solihull, Warwickshire. (Solihull 1111.)
Institute of Fuel, 18 Devonshire-street, Portland-place, London, W.1. (LANgham 7124.)
Institute of Marine Engineers, Memorial Building, 76 Mark-lane, London, E.C.3. (ROYal 8493.)
Institute of Metals, 17 Belgrave-square, London, S.W.1. (BELgravia 3291.)
Institute of Packaging. Apply to Mr. H. Williams, 80 Lancaster-avenue, London, S.E.27. (GIPsy Hill 4859.)
Institute of Road Transport Engineers, 69 Victoria-street, London, S.W.1. (ABBey 6248.)
Institution of Chemical Engineers, 16 Belgrave-square, London, S.W.1. (BELgravia 3647.)
Institution of Civil Engineers, Great George-street, London, S.W.1. (WHItehall 4577.)
Institution of Electrical Engineers, Savoy-place, Victoria-embankment, London, W.C.2. (TEMple Bar 7676.)
Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank-crescent, Glasgow, C.2. (Central 5181.)
Institution of Heating and Ventilating Engineers, 49 Cadogan-square, London, S.W.1. (SLOane 3158.)
Institution of Locomotive Engineers, 28 Victoria-street, London, S.W.1. (ABBey 6672.)
Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, London, S.W.1. (WHItehall 7476.)
Institution of Mining and Metallurgy, 44 Portland-place, London, W.1. (LANgham 3802.)
Institution of Naval Architects, 10 Upper Belgrave-street, London, S.W.1. (SLOane 4622.)
Institution of Production Engineers, 10 Chesterfield-street, London, W.1. (GROsvenor 5254.)
Institution of Structural Engineers, 11 Upper Belgrave-street, London, S.W.1. (SLOane 7128.)
Institution of Works Managers, 196 Shaftesbury-avenue, London, W.C.2. (TEMple Bar 8324.)
Junior Institution of Engineers, Pepys House, 14 Rochester-row, London, S.W.1. (VICtoria 0786.)
Non-Destructive Testing Society of Great Britain, 2 Tomswood-terrace, Barkingside, Essex. (HAinault 5488.)
Physical Society, 1 Lowther-gardens, South Kensington, London, S.W.7. (KENsington 0048.)
Plastics Institute, 6 Manville-place, London, W.1. (WELbeck 5439.)
Reinforced Concrete Association, 94-98 Petty France, London, S.W.1. (ABBey 4504.)
Royal Aeronautical Society, 4 Hamilton-place, London, W.1. (GROsvenor 3515.)
Royal Meteorological Society, 49 Cromwell-road, South Kensington, London, S.W.7. (KENsington 0730.)
Royal Society of Arts, John Adam-street, Adelphi, London, W.C.2. (TRAfalgar 2366.)
Royal Statistical Society, 21 Bentinck-street, London, W.1. (WELbeck 7638.)
Scientific Film Association, 164 Shaftesbury-avenue, London, W.1. (TEMple Bar 4694.)
Sheffield Metallurgical Association, 66 Ringstead-crescent, Sheffield, 10. (Sheffield 62144.)
Société des Ingénieurs Civils de France (British Section), 82 Victoria-street, London, S.W.1. (VICtoria 6838.)
Society of Chemical Industry, 14 Belgrave-square, London, S.W.1. (BELgravia 3681.)
Society of Instrument Technology, 20 Queen Anne-street, London, W.1. (LANgham 4251.)
West of Scotland Iron and Steel Institute, 39 Elmbank-crescent, Glasgow, C.2. (Central 5181.)

Construction

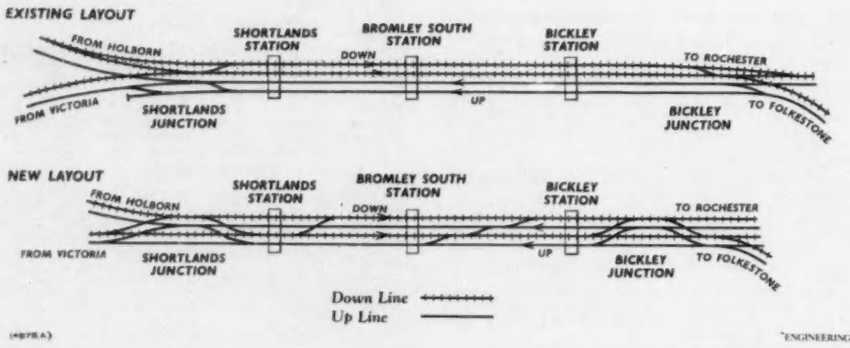


Fig. 1 Southern Region Kent coast electrification plans involve considerable work to improve running. Re-arrangement of the tracks at Shortlands Junction and Bickley will allow increased speeds and less interference by cross traffic.

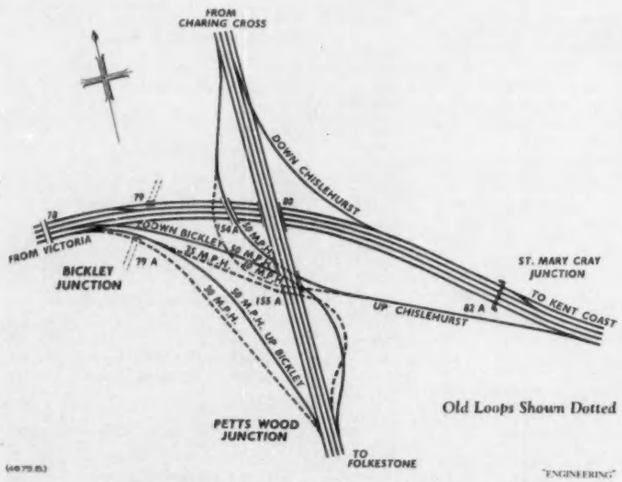


Fig. 2 The Bickley and Chislehurst loops are being re-aligned to give smoother curves and increase running speeds.

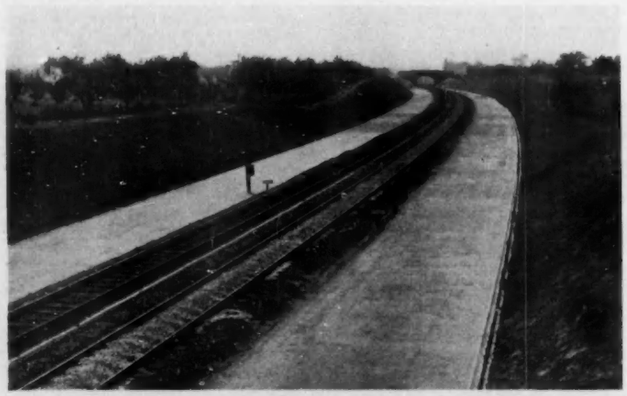


Fig. 3 Between Rainham and Newington work is in progress to form passing loops. In the illustration the stone-dust layer has been compacted ready to receive the track and ballast.

Fig. 4 Along the route about 18 bridges have had to be built or reconstructed. When only 5½ hours "possession" is allowed, then high speed methods must be employed, as here, near Rainham.

SOUTHERN REGION ELECTRIFICATION

It was in 1946 that the Southern Railway announced their plans for the electrification of the lines to the Kent coast. In 1952 the British Transport Commission approved the plans in principle and in 1954 details of the scheme were announced. Work on stage 1 phase 1 is now well advanced towards completion in June, 1959.

The scheme falls into four parts: (1) the actual installation of electrical equipment from Gillingham to Dover (via Canterbury), Ramsgate and Sheerness; (2) track improvements to avoid bottlenecks and allow heavier services; (3) the installation of semi-automatic colour light signalling; and (4) construction of rolling stock and its maintenance installations. In all, over 80 miles of line are involved.

At Shortlands Junction the track layout is being altered to give a clear run through so that trains will not block all tracks when crossing from one side to the other as was the case in the original layout consisting of a pair of up and a pair of down lines. The four tracks are therefore being relaid to form two pairs of up and down lines, which involves drastic resignalling as well as changes to the layout at each end of the section. A comparison of the old and new arrangements is shown in Fig. 1. At the same time re-arrangement of the platforms at Bromley South and similar work at Bickley Junction—again to avoid blocking the tracks when crossing—is also involved. These changes will allow speeds to be raised from 40 to 60 m.p.h. on the Victoria line and from 20 to 40 m.p.h. on the Holborn line. The platforms at Bromley and Bickley are being lengthened to take 12-car trains.

To obtain improved running between Bickley and St. Mary Cray, the whole junction is being redesigned as shown in Fig. 2. Three of the loops are being diverged, involving extensive earth removals, and seven new bridges and culverts are being constructed. The changes will allow speeds to be increased from 30 to 50 m.p.h. over the new loops. Four tracks will be laid as far as Swanley and the station at St. Mary Cray will have two island platforms instead of the present staggered arrangement.

The additional tracks to be laid here will involve the reconstruction of eleven bridges, as well as the nine-arch viaduct at St. Mary Cray. Several of the existing bridges are too narrow to span the four tracks, and will have to be demolished. Owing to the very short time of "possession" allowed, about 5½ hours on a Saturday/Sunday night, explosives are being used.

Again with the object of improving the running facilities, passing loops are being constructed between Rainham and Newington, so that express trains can run past stopping trains at these stations. The platforms at Rainham have already been lengthened to take eight-car trains and those at Newington are to be done. As between St. Mary Cray and Swanley, some bridges have to be reconstructed. Other works in the area include doubling the tracks on the Sheerness branch to give passing loops between Middle Junction and Swale.

For the new services, new rolling stock is being built. The express routes will be run by four-car through-corridor sets similar to those recently introduced on the Brighton line. It is planned to run hourly services from Victoria to Ramsgate and Dover with trains made up of three of these units, which will be divided at Gillingham. The buffet car portion will then go on to Ramsgate and the remainder to Dover. For this service 53 four-car sets are being built.

For the intermediate and stopping service, 62 two-car sets are to be built of the type now used on the Sevenoaks service; that is, a semi-saloon motor coach drawing a corridor trailer. In addition, to handle the freight trains there are to be built 13 electric locomotives; 45 Diesel locomotives are also to be built, again mainly for freight working.

In Parliament

AIRCRAFT CONTRACTS

Inevitably, as the Christmas recess approaches, more and more time has to be given in both Houses of Parliament to matters of mainly political interest. Nevertheless, the two Houses continue to find time to consider many subjects of predominantly industrial and scientific importance.

One of these occasions occurred in the Commons last week, when a brief discussion took place on the present and future prospects in Britain's aircraft industry. Mr. Aubrey Jones, the Minister of Supply, told the House that the industry faced a difficult and challenging period. On the one hand, there had been a substantial reduction in the demands for military aircraft since the height of the rearmament programme had been passed. On the other hand, the volume of production of civil aircraft during the next few years depended upon the success of the manufacturers in selling the aircraft which are at present in course of production or development. While he was optimistic of their success, it was unlikely that any increase in the manufacture of civilian aircraft would wholly offset the decline in the production of military machines.

AERONAUTICAL RESEARCH PROBLEMS

An inter-departmental examination of the problems involved in this transition period, including the future of Government policy in respect to aeronautical research, was now being made, Mr. Aubrey Jones informed the House. The Transport Aircraft Requirements Committee, which kept all possible outlets for British transport aircraft under review, was, in the present circumstances, inviting the Society of British Aircraft Constructors into its discussions.

It was also desirable that the aircraft industry should re-shape itself into stronger units. He had accordingly intimated to the industry that, in placing orders for future requirements, the Government would be influenced not only by the quality of design but also by the resources, technical and financial, available to complete projects quickly and successfully; and that, in so far as these criteria were not met with in particular cases, the Government would require the chosen contractor to work in association with one or more other contractors.

SCOPE FOR A WIDER INQUIRY?

Mr. Frank Beswick (Labour/Co-operative) thought that the statement made by Mr. Aubrey Jones would do something to offset any impression there might be that he was not interested in the industry's troubles. But was this negative approach, of withholding orders from certain firms, a good enough method of planning? Also, was the Minister satisfied that the inter-departmental inquiry was being conducted on a sufficiently high level? Would it not be better to get some outside people, of the highest character, to look into this industry's affairs?

A point stressed by Mr. Ian Mikardo (Labour) was that whenever redundancy threatened in an industry, the Minister of Labour urged that the trade unions concerned ought to be brought into consultation at the earliest possible moment. Yet the aircraft manufacturers had been discussing for a long time the making of joint arrangements for running down the industry, without having said anything to any trade union. In one case, a group of technologists at one aircraft factory first learned of their redundancy through a B.B.C. news broadcast.

Replying to these and other points, Mr. Aubrey Jones said that no one was more conscious than himself of the importance of the aircraft industry to the future of Britain. The essence of the problem was that there had been a decline in the total of military orders and it was not a question of withholding orders deliberately. He was satisfied that the inter-departmental inquiry was being held at a sufficiently high level. The most important aspect of the matter was that there should be a speedy decision regarding the industry's future and the wider inquiries of this kind were made the less likely was it that speedy decisions would be reached. He was not aware of the case mentioned by Mr. Mikardo, but he agreed that it was desirable that there should be consultation in all practicable circumstances.

With regard to the engineers, technicians and scientists who were likely to be displaced from the aircraft industry, these highly-skilled personnel were in much demand elsewhere and it was very important that their services should be used where they were required. He did not agree that aircraft designers and technicians should be recompensed on redundancy, in the same way as had been arranged for the Armed Forces. The two cases were surely quite different.

IRON AND STEEL PRODUCTION

Under an agreement signed on November 25 and laid before the House on December 3, the United Kingdom duties on the principal iron and steel products are to be reduced to 10 per cent., with alternative specific rates. In this connection, Sir David Eccles, the President of the Board of Trade, told Mr. Alan Green (Conservative) that the countries in the European Coal and Steel Community, for their part, would introduce new rates, which would mean substantial reductions in some cases. Britain's obligations under the agreement would become effective when all the signatory countries had ratified it, and the necessary Orders in Council to give effect to the new United Kingdom duties would then be introduced.

CLOSURE OF WELSH STEELWORKS

Employment problems concerning the closure of certain old-type steel and tin-plate works were referred to by Mr. Iain Macleod, the Minister of Labour and National Service. He told Mr. Herbert Gower (Conservative) that the tin-plate, sheet steel and steel works in South Wales which were expected to close this year employed some 8,000 workpeople at the beginning of 1957, of whom 3,800 had been discharged by the end of October. About 400 unemployed operatives in east South Wales had good prospects of being placed quickly in suitable work.

The immediate prospects of about 4,000 operatives employed in works which were expected to close in the near future in west South Wales were uncertain, but a number of industrial developments were in progress within reasonable daily travelling distance of most of the areas concerned and, at a later date, as these developments were completed, a substantial number of new jobs should become available. When the decision was announced last July to close the Mellingriffith Works at Whitchurch, Glamorgan, full facilities were given by the management to officials of the Ministry of Labour to register for other work the persons involved. Although more than 360 workpeople had been discharged, only 19 were still registered as unemployed. It would be premature, however, to make an estimate regarding the subsequent employment prospects with respect to the 12,800 persons employed in certain other old-style tin-plate and steel works, about the future of which works decisions had not yet been made.

BACKGROUND TO THE RAILWAY ACCIDENT

The collision on December 4 at St. Johns, Lewisham, the third worst railway accident to occur in the United Kingdom, was the gravest for casualties on any of the lines formed into the Southern Region at nationalisation. Previous to that, the collision in 1947 at South Croydon, with 32 fatalities, had been the most serious since the derailment at Salisbury, with 28 deaths, more than 40 years before.

No better example of the fortuitous character of the consequences of an accident could be found than the present case, with its fatality list of 88, for the collision apparently was rendered more violent than it would otherwise have been by the fact that the brakes had been applied on the standing train. The consequent buckling of the colliding train dislodged the bridge pier and the falling girders brought about the heavy death roll; this might have been even worse had the train on the line above been running in the ordinary manner. Fog and darkness made it extremely difficult to bring assistance to the sufferers.

This section of route is equipped with continuous track circuiting and colour-light signals, brought into service in 1929 as an extension of the work completed at and near London Bridge in the previous year, and there has been no collision fatal to passengers there in all that time, during which some 1,000 trains have passed through St. Johns daily. The number of electric trains alone dealt with daily at London Bridge, Waterloo and Victoria, to mention no other stations, amounts to over 4,000 so that the level of safety attained by this method of operation is certainly very remarkable. It is essential to keep a sense of proportion and bear such facts in mind when considering the present grievous calamity.

The question of whether a fog service was or was not in operation has nothing to do with the case. Unless there was, as remains to be investigated, a particularly bad breakdown in the signalling equipment, there would seem to be but one explanation of this case, namely that two warning and at least one—perhaps two—stop signal indications protecting the obstruction were passed by the steam train driver. Whether some peculiar conditions on the footplate contributed to that, if indeed it did occur, must of course be a matter for the official investigation. Fog signalmen, necessary to supplement the older semaphore type signalling, have not been found to be required with colour-light signals, which are usually placed practically at driver's eye level, and hitherto no form of automatic train stop or train control has been applied to such signals on the Southern lines.

On November 30, 1956, the Minister of Transport and Civil Aviation gave formal approval to the British Transport Commission's magneto-inductive "warning" type control equipment, after extensive trials between London and Grantham, and a programme for all main routes is being pressed forward as rapidly as possible, as stated in the recently published annual report for 1956 of the Chief Inspecting Officer of Railways, Lt.-Colonel G. R. S. Wilson. This covers the equipping of some 1,300 miles of route and the fitting of some 10,000 locomotives or other motive power units by the end of 1962. When used with the form of signalling seen at St. Johns this apparatus sets a horn sounding and initiates a brake application at the approach to every signal—unless it is showing green, when a bell rings—until the warning is silenced by the driver actuating an acknowledging handle, failing which, of course, the train is brought to a stop.

It may be observed that during 1956 no passenger out of over 1,500,000,000 lost his life in a train accident, properly so called, in Great Britain and that of the 37 mishaps arising from inattention to, or misinterpretation of, signals, seven might have been avoided had automatic train control in the form now adopted by the British Transport Commission been in service.

The Human Element

Intrigue in the Limelight

The successful efforts of the Communist-dominated Electrical Trades Union executive to arrange amendments in the union's constitution to suit its own ends has lifted the domestic troubles of the union into the national arena. The executive have tried very hard in the last few days to play the matter down as a domestic affair of no public consequence but they have not succeeded.

Nothing would play more into the hands of the Communists at this stage than to allow either the Government or the Trades Union Congress to interfere in the affair without the consent of the union members. Any attempt from outside would close the union's ranks at a time when there is some prospect that the anti-Communist group would be able, with patience, to unite the majority of the members to vote out the Communists at the next election. They will require two years to the next election to do it and there is a good deal of patient organisation work to do among the rank and file on the way. The only help that national publicity provides is to help keep the issue alive when the executive dearly wish it to be dead.

Co-operative America

The philosophy of the retail co-operative as practised originally by the first shop in Rochdale is not usually associated with the United States of America. The idea of the farmers' co-operative is at first sight more consonant with American ideas. This is not altogether true, however.

As Mr. Robert L. Smith of the Co-operative League of the U.S.A. has recently said, the American idea of co-operatives owes something to several countries—especially Britain, Scandinavia, Germany and Canada. The idea of co-operative retail stores came from this country, housing from Scandinavia and credit unions from Germany and Canada. To-day, the co-operative idea has developed in all these directions in the United States. On the retail side, there are supermarket co-operatives, although the growth of the retail idea is concentrated in certain areas. Good work has been done in slum clearance by housing co-operatives in such places as New York. Financing retail expansion is sometimes undertaken by co-operative insurance companies. It has taken some time for organised labour to take to the co-operative idea, but in housing and health schemes there has been a good deal of progress in recent years. In Ohio one of the retail supermarkets run as a co-operative was sponsored by a powerful trade union. A similar idea may flourish under a different name. Even the "divvie" is called "a year-end patronage refund," suggesting (which appears to be true) that the social stratum in the United States using co-operatives is a slightly higher one than in this country.

Lay-Offs in America

A round of cut-backs and lay-offs has begun in the United States and Canada. In Ontario, Ford, General Motors and Chrysler are beginning to discharge workers on account of falling sales. In Detroit there are rumours of similar steps being taken shortly. The industry still awaits the reaction of the public to its 1958 models but with increasing nervousness. This is the key to the employment situation in the next few months. If redundancy is declared on a large scale there could be a sharp cut in consumer expenditure followed by really severe unemployment. It also has a bearing on the emigration problem discussed in our leader of November 22.

So far steel and the railways have suffered most. Two major railways, New York Central and New York, New Haven and Hartford, had cut down their labour force due to a falling volume of freight. Employment has also fallen in the railways' rolling stock building and repairing workshops. New York Central's East Rochester works now employ only 600 people compared with 1,600 a year ago. The steel industry is working at only slightly over 70 per cent. of rated capacity. The recovery anticipated during the autumn has not materialised and it is expected that most companies will shortly have to do more than reduce the working week. Lack of orders led the Colorado Fuel and Iron Corporation to reduce theirs from 40 to 32 hours for 8,400 workers. Those are the signs of what could spread like wildfire if nothing were done to check the downward trend in the United States economy.

Falling Forces

Service in the Armed Forces is failing to attract sufficient numbers to produce even a small regular force by 1962. In that year it was hoped that 165,000 regular soldiers would be serving, mainly on six- or nine-year engagements. This would require about 146,000 other ranks, who could be expected to serve for just over two years (the pre-war average) except for 3,000 on three-year engagements. On this basis it would be necessary to recruit 19,700 men a year, or 1,640 a month. In October, which is normally a peak month for recruiting, only 645 recruits signed on for six- or nine-year engagements. Two and a half times this number would be needed to achieve the Government's target.

The reason for this failure to attract adequate numbers is unlikely to be solely the inadequacy of pay and allowances. Nor is it likely to be industry's clamour for more recruits. Less full employment would probably affect recruitment into the Forces but not to a major extent. One of the main factors in the considerable shortfall in the October figure compared with October, 1956, is probably the change made in the minimum regular engagement, which became six years instead of three. National Service men appear to be less attracted by the three-year engagement, in spite of the Regular rates of pay it offers, now that it means having to soldier on beyond the end of the call-up. Few will risk tying themselves to a uniform for six years.

The recent redundancy of officers and the amalgamation of famous regiments has doubtless played a part in cooling off the ardour of the young enthusiast. This is a period of rapid change in defence. The lack of security concerning long-term engagements may well be the main reason for the failure of the recruitment drive.

Tax-Man and Director

The Chancellor of the Exchequer is severely taken to task by the *Director*, the journal of the Institute of Directors, for widely penalising the people who run their own companies. In 1947, when profits tax was introduced, it was thought decidedly un-British to distribute very much of a company's profits. Therefore the distributed profits tax was invented, giving a definite incentive to plough back into the business. But it was realised that directors who controlled their own companies could easily dispense with paying out dividends and vote themselves large salaries instead. A limit was therefore imposed to the remuneration which directors of controlled companies could receive. This was either 15 per cent. of the profits or £2,500 for "one-man" companies, £4,000 for two directors, £5,500 for three and £7,500 for four or more.

These limits which were imposed in 1952 remain unchanged to-day. If they are exceeded, the excess is not allowable for company tax purposes, is liable to the full rate of profits tax and of course to surtax by the director concerned. The *Director* argues strongly that the value of the £ has fallen and that there is therefore a strong case for raising the limits. Moreover, recent legislation makes it impossible for directors not to distribute profits unless the Special Tax Commissioners agree that they need not do so. The directors of a company controlled by themselves have therefore little alternative. They must distribute what they earn and on these earnings they must pay profits tax, income tax and surtax. Does the Chancellor think this equitable, asks the *Director*, or "has he given any thought to the matter at all?"

Some Slack in the South East

Unemployment has increased slightly in Greater London and the South East, and much less overtime is being worked. The Regional Board for Industry reported that the registered unemployed had risen to 49,962—5,600 more than at the same time a year ago. Since mid-October there has been a further slight increase. But there is no appreciable change in the number employed and unemployment remains at less than 1 per cent. of the insured population, compared to 1·3 per cent. for the country as a whole.

The slack has occurred mainly in the printing, paper, furniture and clothing industries. Radio and television, motor vehicles and firms producing capital goods remain very busy. For the latter the evidence of a slack is confined to a reduction (welcomed by many) in the size of the order book. Unemployment is unlikely to develop in those industries for a year at least but if there was a sudden fall in the sales of cars and electrical appliances, as might take place after the Christmas holiday, it is highly improbable that redundant workers could be absorbed by other industries as was the case last year.

The figures for the country as a whole show the same general trend. At 317,000, mid-November unemployment amounted to 1·5 per cent. of the total labour force, compared with 1·2 per cent. a year ago. The number of unfilled vacancies also fell, from 274,000 in October to 252,000 last month. Much of this was the result of seasonal falls in employment in agriculture and fisheries, which was not fully taken up by manufacturing industry and the distributive trades although each gained about 20,000 workers. We are, it would seem, coming to the end of "over-employment."

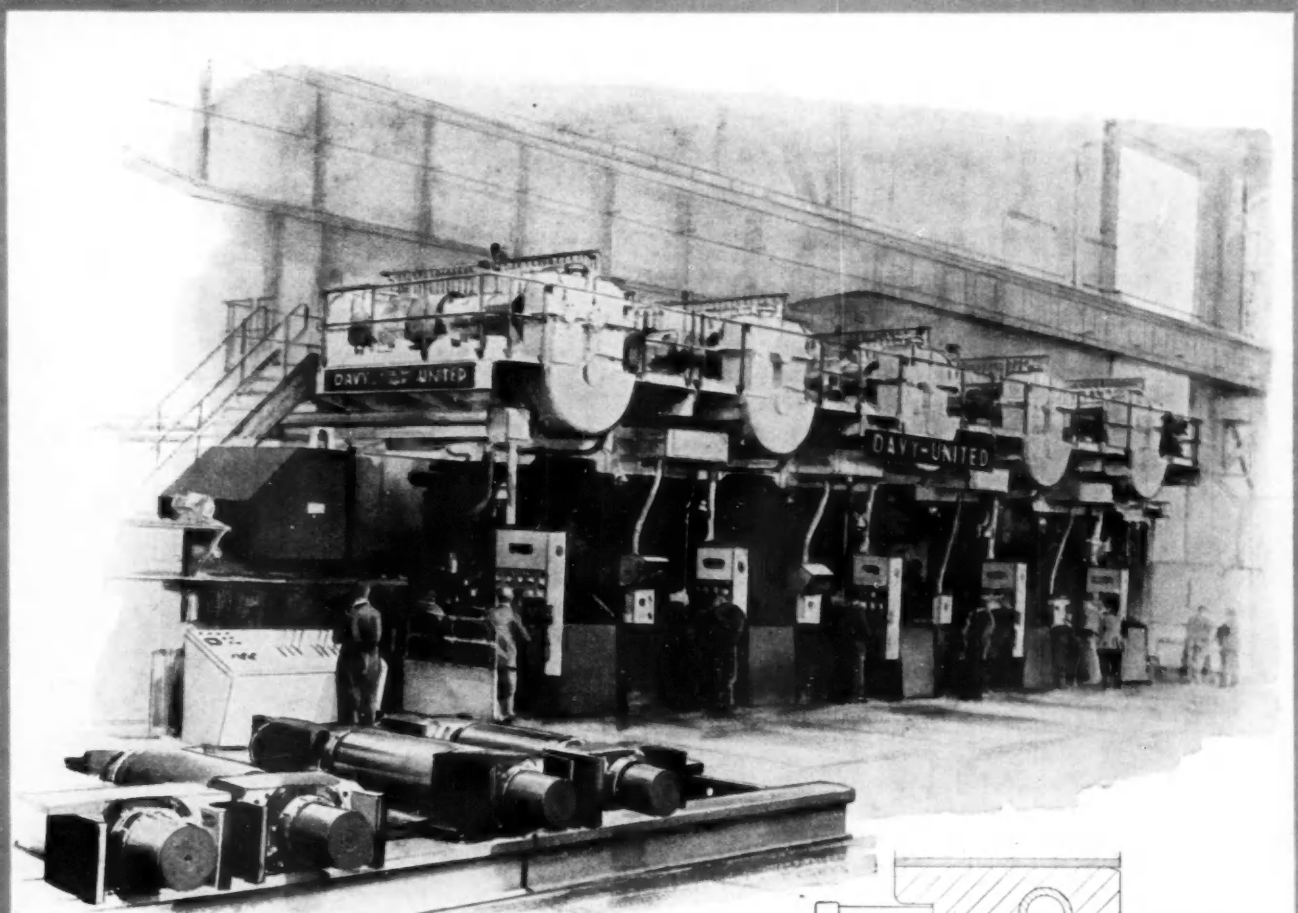
Of Mice and Missiles

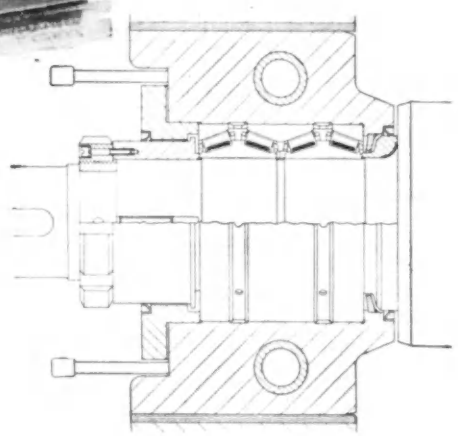
Emulation can be a useful spur to the young. The news, however, that some American schoolboys, assisted by a school physics teacher in what is called an advisory capacity, have sent up a rocket some 1,600 ft. with a mouse inside arouses mixed feelings. This is a toy experiment involving cruelty to an animal (it died when the rocket crashed) and no one yet has succeeded in drawing the line between justifiable cruelty and just cruelty. Scientifically, the experiment proves what has been known for a long time, namely, that if you drop a mouse 1,600 ft. in free fall you will kill it.

So far as the United States as a whole is concerned, the incident may be some balm to self-esteem. Sending animals up in rockets is clearly child's play. That is the most that can be said for the affair. But if children, encouraged by adults with more curiosity than sense, are to be allowed to shoot animals at will into the air without even the excuse of scientific experiment, another nail may be driven into the human coffin. Respect for life is fundamental to that delicate stability on which human society to-day depends. But taking ourselves too seriously can be as dangerous. The woman who appeared at the Soviet Embassy wearing a fox fur to protest about the dog in Sputnik II provided her own comment.

ENGINEERING

An Illustrated Weekly Journal





On the five-stand cold-reduction mill at Velindre

This five-stand cold-reduction mill built for The Steel Company of Wales, Velindre, by Davy and United Engineering Company Limited, is equipped with Timken tapered-roller bearings on the work roll necks and in the screw-down mechanism. The illustration shows the mill with spare work roll assemblies in the foreground, ready for a work-roll change-over.

The sectional drawing shows a typical arrangement of Timken tapered-roller bearings on work rolls.

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